JOURNAL OF

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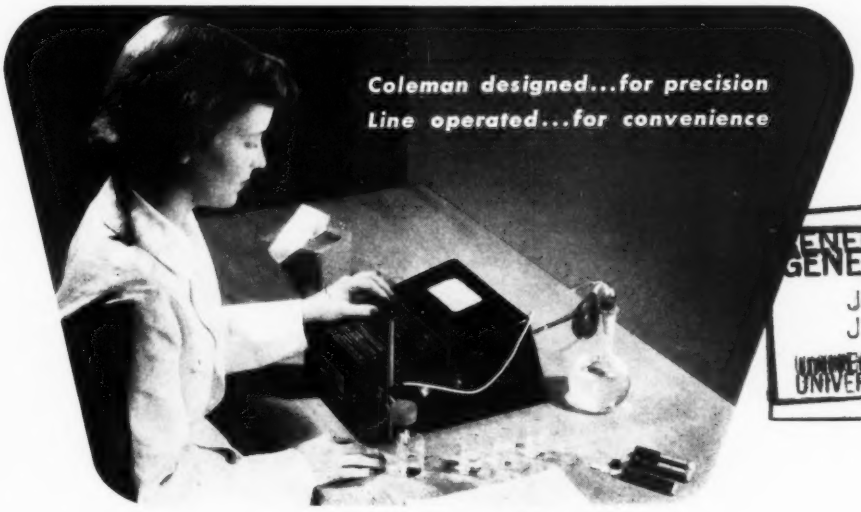

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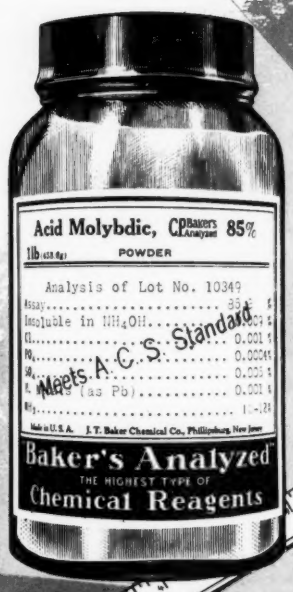

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Fig. 1, showing Small size in position in Water Bath of Stormer Viscosimeter.

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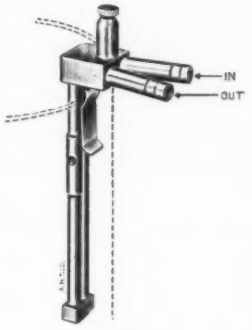

9937.

Fig. 2, showing Large size in position in a beaker.

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Fig. 1, showing beaker inserted in a jar.

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Fig. 2, showing use of Forked Insert for use in supporting test tubes.

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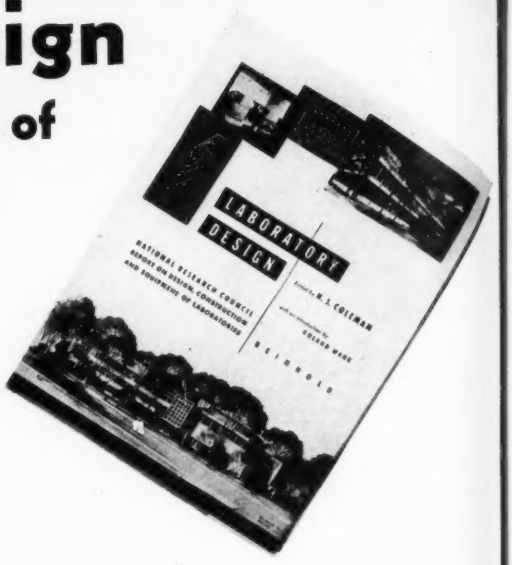

edited by H. S. COLEMAN, assistant director, Mellon Institute; introduction by Roland Wank, architect

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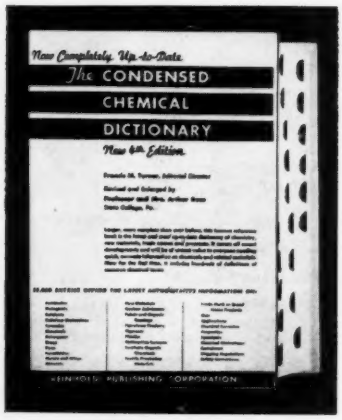

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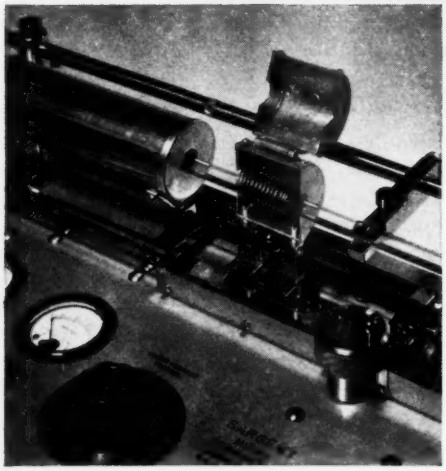

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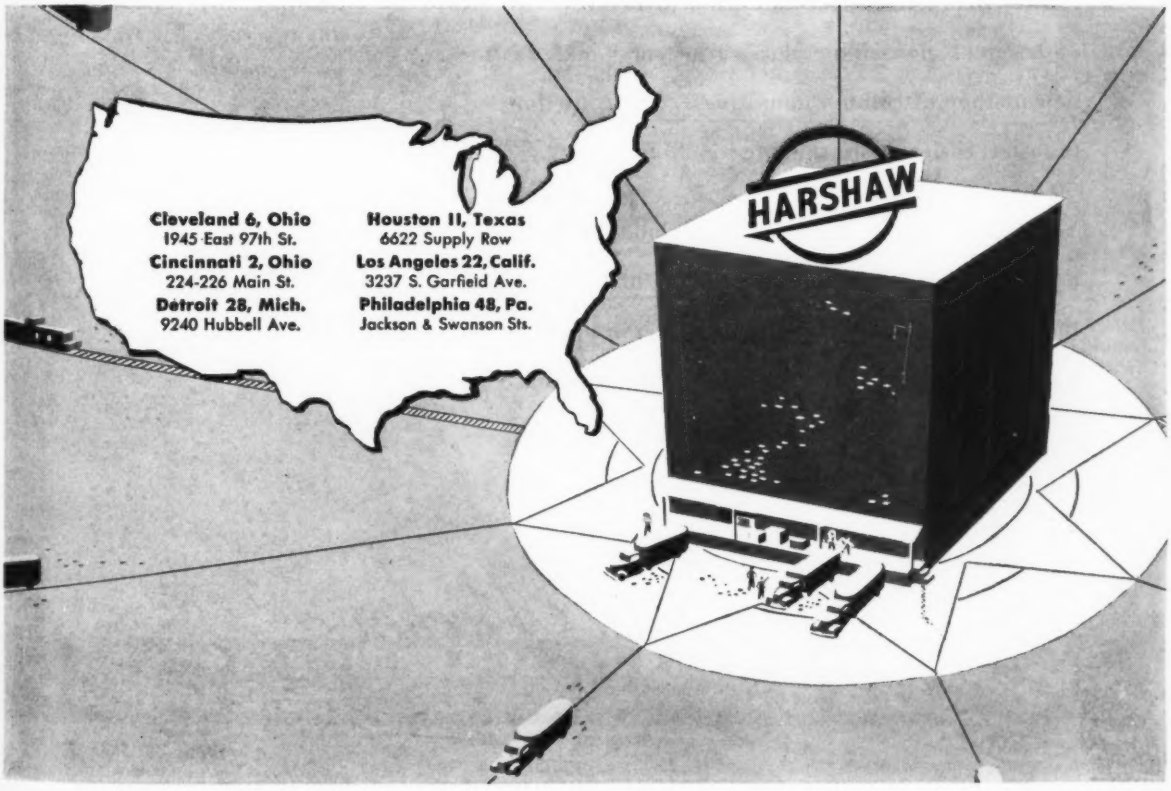

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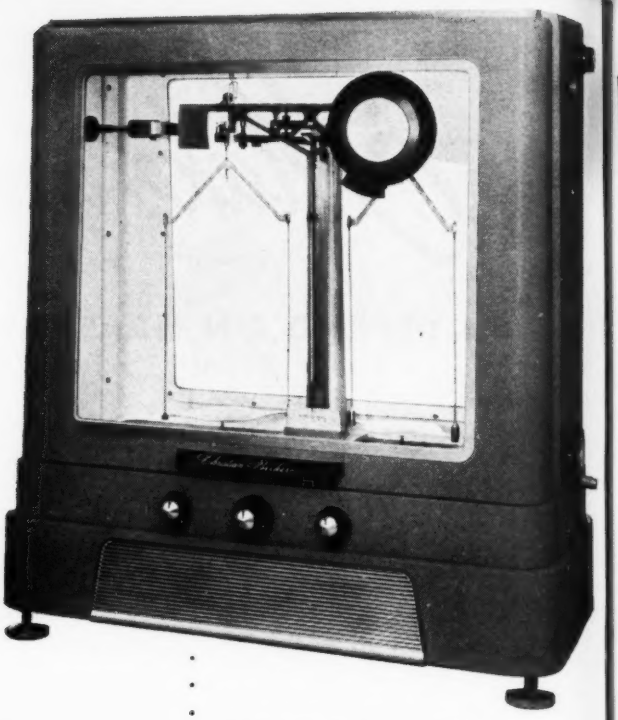

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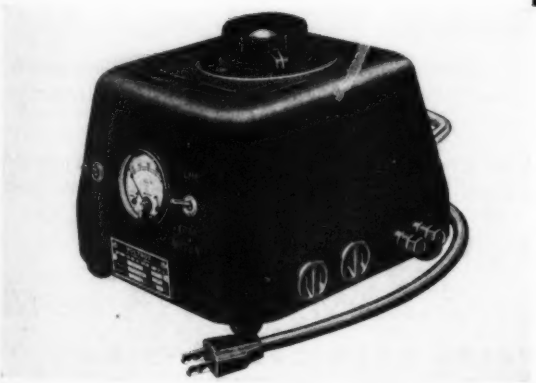

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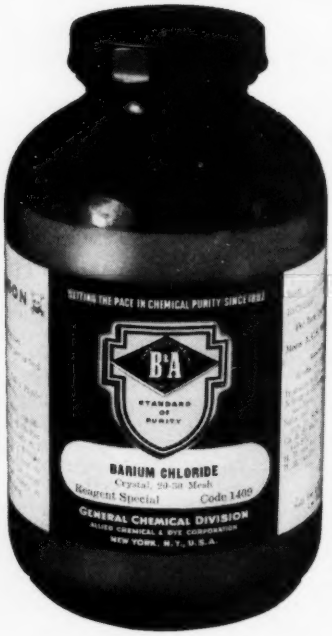

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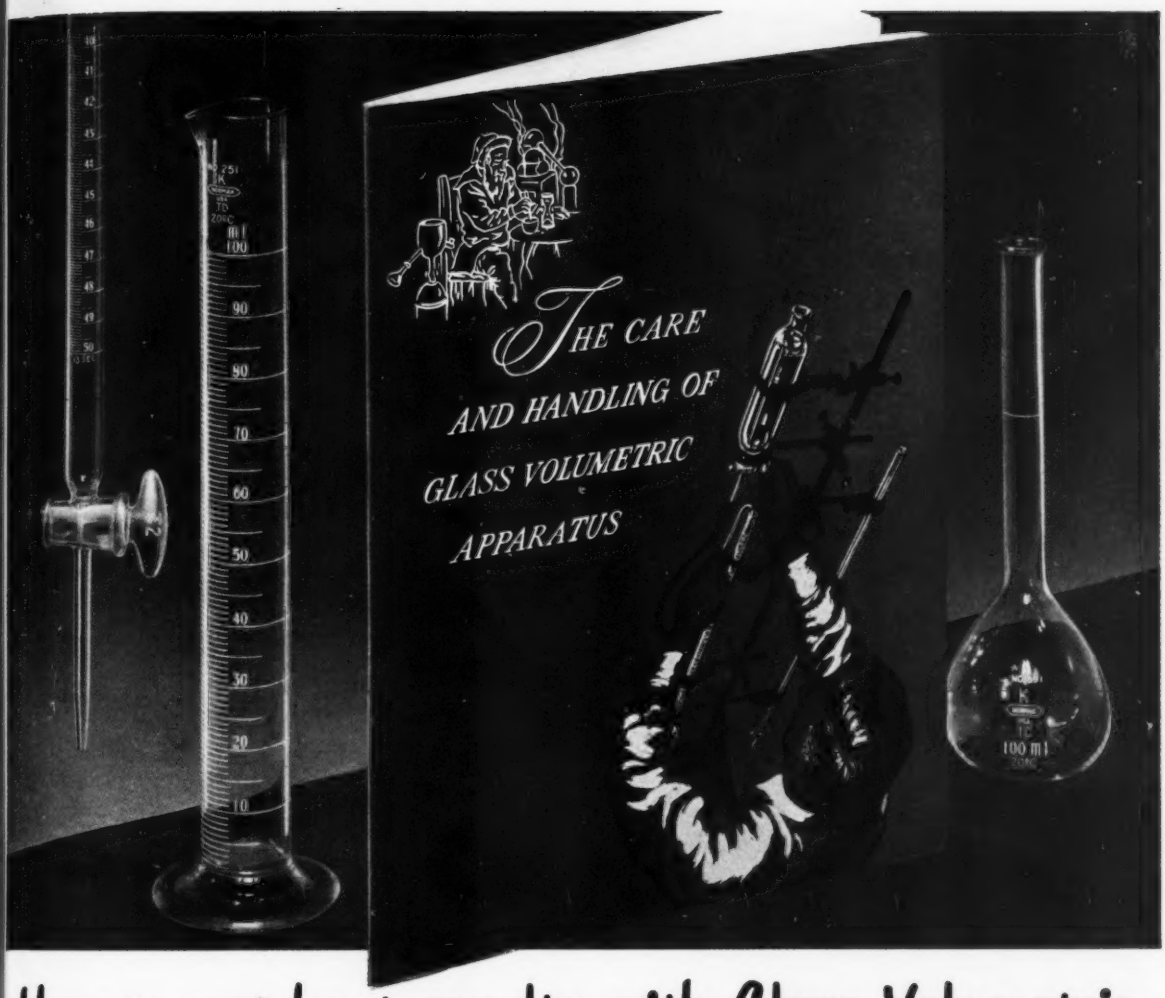

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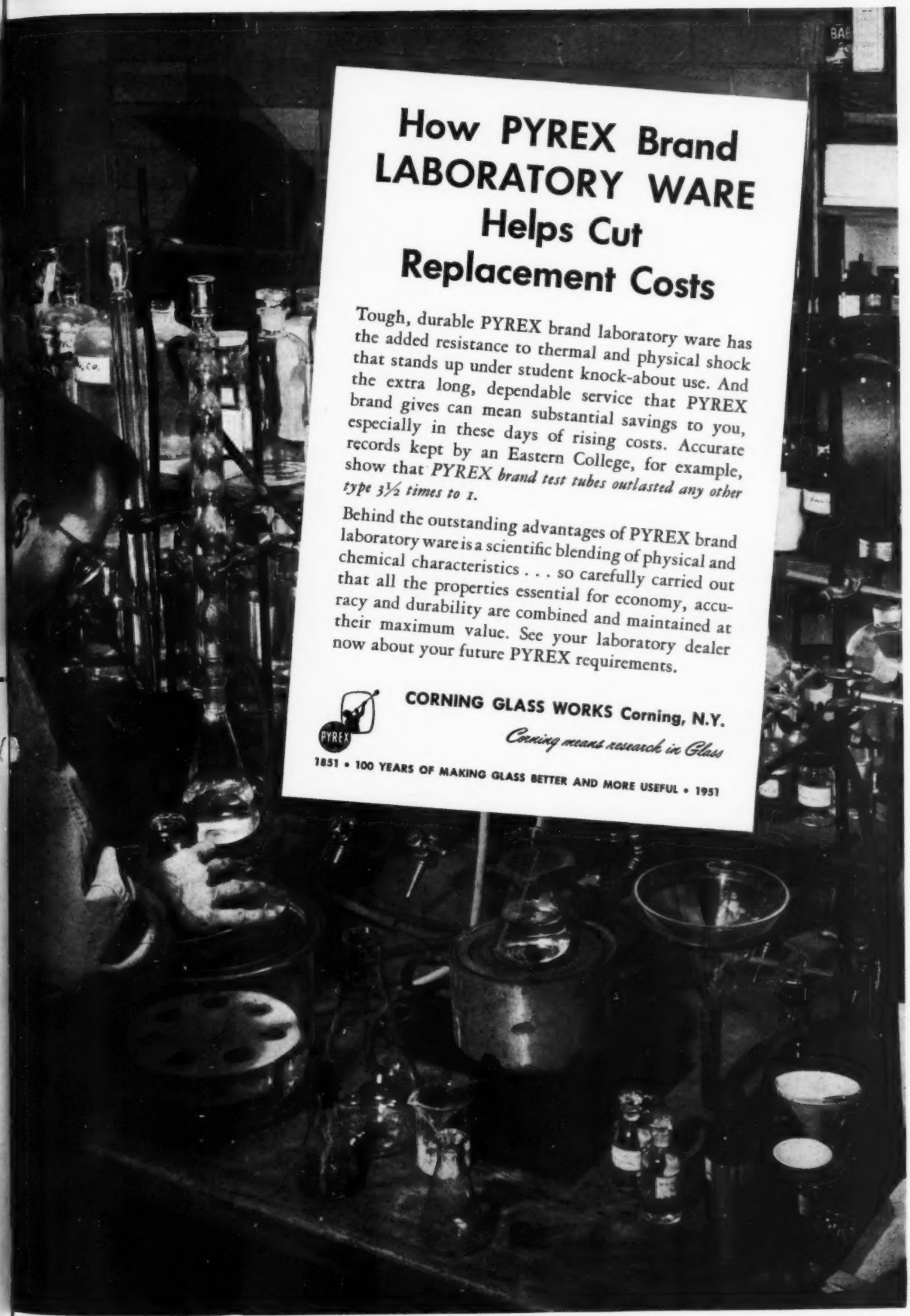
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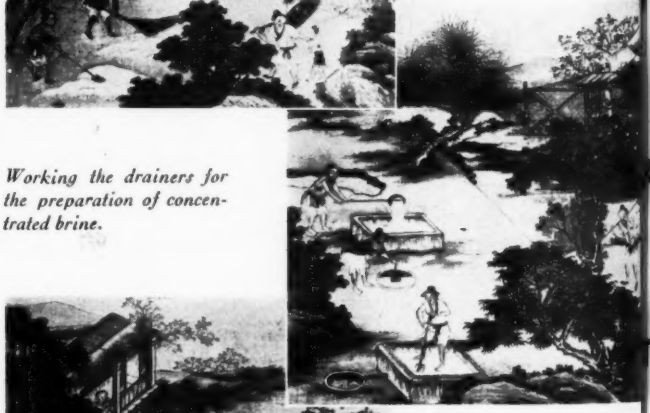

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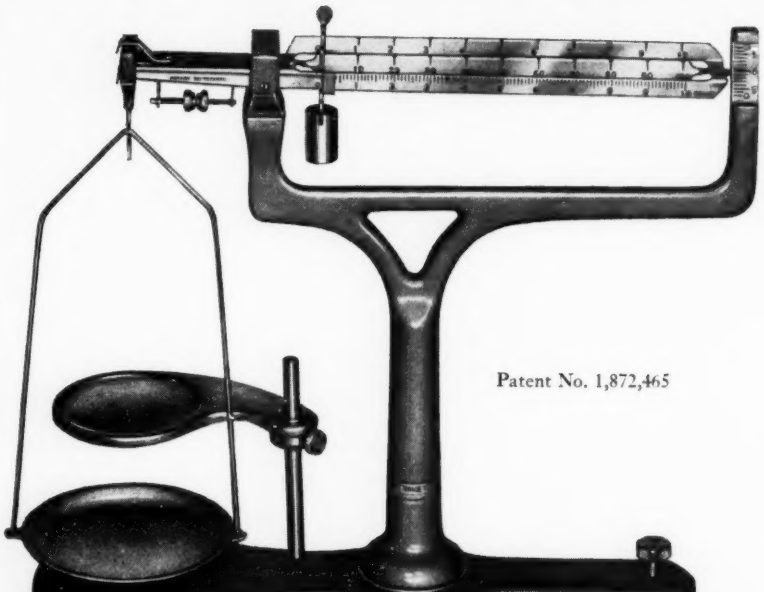

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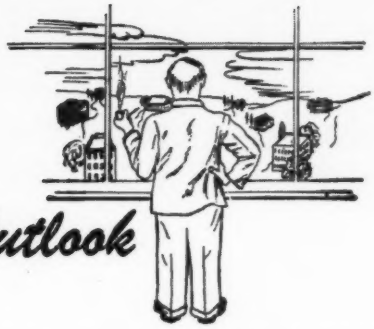

Editor's Outlook

I have a friend—a physicist—who, when asked to define physics, says: "Physics is what physicists *do*." This sounds like a pretty good definition and perhaps deserves to be extended to cover scientists in general. If this be true, a liberal education in the "scientific method" is less a matter of philosophical discussion than of day-by-day observation of what goes on.

Elsewhere in this issue (pages 300 and 304) are two articles which deal with the method of science and which present extreme or contrasting points of view. Neither, however, precludes the truth of the other—as far as it goes. The first argues, rather conventionally, that inductive reasoning is the basis and method of science and that the habit of this kind of thinking should be one of the objectives of general education. Certainly such a habit, more widespread, would help to alleviate some of the world's troubles.

The second article is perhaps wrongly titled. Only a scientist of Walden's stature and prestige could risk suggesting the initiation of "Lady Luck" into the scientific fraternity. His thesis is rational only in the light of Pasteur's oft-quoted remark: "Chance favors only the prepared mind." The real argument here is that the "prepared" mind comes to its illuminating conclusions not only by following regimented procedures but also sometimes in its own mysterious, subconscious way, when free from all external restraints. Call this what you will—intuition, illumination, mysticism, subconscious thought, deduction—nevertheless, Walden has collected an impressive array of examples to show that this is often what scientists *do*. A lesson worth deriving from this is that the mind, like the human spirit (if there be a difference), is at its best when it lives in an atmosphere of freedom.

W. I. B. Beveridge, in the same article from which I quoted last month,[1] has something to say on this question:

> First, it may be necessary to change radically the student's conception of research. He has been taught science as a logically arranged scheme of knowledge and he has been trained to think logically about it. His natural inference is that knowledge advances mainly, or even only, by the application of purely logical processes. All his training has been towards a detached, objective mode of thought and he has now to learn that, although this training is valid for the design and execution of experiments and for the assessment of results, there are other research activities which involve an intensely personal or even frankly subjective approach. It may surprise him to learn the varied scope of research and to realise that erudition is not so all-important as the examination system may have led him to believe. He might reasonably be expected to profit from being introduced to new habits of thought in which he is as yet untrained. The fact that there are, for the scientist, dangers in subjective thinking is all the more reason why he should be told something about it, because he is going to use it in any event. The sooner he realises this the better.

After expressing some surprise that students of science seldom receive any instruction in the "scientific method" he goes on to say:

> The reason for this state of affairs is that the scientific method has for some reason been regarded as the province not of scientists but of philosophers and as developed by them it is sterile as a means of discovering new facts and theories in science. I think the error lies in the logician's attempt to make research a logical science whereas in fact it is a creative art . . . At first sight it may seem paradoxical to say that scientific research is an art; but it is a conclusion which I do not think can be avoided and most research workers on reflection see the truth of it. The difference between a science and an art is that a science in the restricted sense is objective, rational and systematic and in practising a science one does things under guidance of conscious reasoning, whereas in an art there is a large subjective element and one's activities are dictated to a considerable extent by unconscious mental processes.

This implies, I think quite rightly, that whereas science itself is rational, objective, and logical, the method of scientific discovery, by which its conclusions and formulas have been reached, is not so closely restricted. Bridgman has said that the scientific method is doing one's damndest with one's mind, no holds barred.

Our teaching objective is presumably to enable one to distinguish between reliable conclusions on the one hand and propaganda, persuasive advertising, and dogmatic assertions on the other. What *is* important in making this distinction? First, skepticism. We accept nothing permanently merely because someone has said it. Second, inspection and justification. Every new conclusion, however arrived at, by induction, deduction, intuition, or "hunch," is tested for compatibility with reliable facts which have been established by reproducible observation. If the conclusion is a generalization or summing-up of such facts it must be an accurate summary of them; if it is an attempted explanation of existing phenomena it is only necessary that it be adequate and self-consistent, either in the form of a mental picture or a mathematical expression. Third, tentative acceptance. *All* conclusions and statements are perpetually on trial and are abandoned when no longer in accord with objective evidence.

Certainly, the world would profit greatly if many people (I hesitate to say *all*) were to develop the scientific habit of thinking, and if some (at least) were to cultivate the *art* of research.

[1] "Teaching the art of research," *Research*, **4** 97 (1951).

NILS GABRIEL SEFSTRÖM AND THE DISCOVERY OF VANADIUM

SVEN GÖSTA SJÖBERG
Centrallasarettet, Eskilstuna, Sweden

AT THE only factory in Sweden for the production of vanadium pentoxide (V_2O_5), owned by the Falun Copperworks, in the mining town of Falun in Dalecarlia, there occurred a few years ago some cases of illness due to the handling of the material. In 1947–50 I carried out an investigation on this occupational disease, which up to then had been fairly unknown and unclear.[1] On studying the history of vanadium I found that the discoverer of the element, the Swedish scientist Nils Gabriel Sefström (1787–1845), one of Jöns Jacob Berzelius' (1779–1848) most prominent pupils[2] had worked for sixteen years in this very town, Falun.

The metallic element vanadium occurs fairly extensively in nature, although in very small concentrations. The crust of the earth is said to contain approximately 0.01 per cent of vanadium. It is most commonly found in iron ore rich in titanium, and in carnotite, hydrated potassium-uranium vanadate. Vanadium occurs also in the ashes of some plants (sugarbeet, vine, oak, beech), and in some lower marine animals (*Ascidiacea*) in which it is probably contained in some enzymes essential for life. The relatively high vanadium content in coal and some mineral oils is considered to be of such organic origin.

Vanadium is described as a very hard and brittle metal of steel-gray color. Because of its hardness and its ability to combine with iron forming an alloy, ferrovanadium, it has become very useful and is in great demand in the manufacturing of hard steel for machines and tools. It is also used as a catalyzer in chemical industries, *e. g.*, in the manufacture of sulfuric acid. Compounds of vanadium are used as mordants in dyeing, preparation of ink, as accelerators in the drying of paints and varnishes, in insecticides, photographic chemicals, and in glass manufacture. The fact that in Germany the consumption, according to available figures, increased from 150,000 kg. in 1934 to 400,000 kg. in 1937 and to 5,000,000 kg. per year during the last war, and in England from 170,000 kg. in 1936 to 2,500,000 kg. in 1943, is further evidence of its rapidly increasing importance. It is also a matter of considerable economic importance, as vanadium is as yet comparatively costly.

The ill effects of vanadium compounds are also important and interesting. As already mentioned, V_2O_5 may give rise to an occupational disease. The main symptoms are transient irritation of the mucous membranes of the upper respiratory tract and the bronchi, with nasal catarrh, irritation of the throat, and a cough with wheezing sounds over the chest, attended by dyspnea and fatigue, attributed to exposure to vanadium pentoxide dust. Intercurrent pneumonia has been demonstrated in a few cases. The condition is relatively mild and no deaths have occurred. Nor have any diseases of the lungs been demonstrated because of dust (pneumonoconiosis), such as in silicosis or cemented tungsten carbide pneumonoconiosis, although slight chronic-catarrhal changes in the mucous membranes of the respiratory tract may develop. Cases of occupational eczema have occurred. It has been found that vanadium is absorbed and excreted in the urine, but no general poisoning has been demonstrated, although it is known that soluble vanadium compounds in large doses have a marked toxic effect in experimental animals. An interesting fact is that the aforementioned catalytic action of vanadium may also be traced experimentally in some enzymic processes.

The corrosive effect of vanadium in oil-heated boilers (as the element is contained in the ashes of mineral oils) is of interest in this connection. Here it is a matter of catalytic action with oxidation of SO_2 to SO_3, although the formation of vanadates probably contributes to the corrosion.

The raw material used in the manufacturing process is iron-ore slag from the Domnarfvet Ironworks. This slag contains about 12 to 17 per cent of vanadium. The bulk of the finished product is delivered to Söderfors Ironworks for the manufacture of hard steel.[3] Briefly, V_2O_5 is produced as follows: The slag is crushed, pulverized, and mixed with soda, whereupon it is roasted at 600–800°C. which renders the vanadium soluble. This is followed by extraction with warm water, precipitation of V_2O_5, and drying of the product. The rate of production is comparable with the figures for England and Germany, already quoted.

Surely Sefström himself could never have foreseen the consequences of his discovery. It is significant that in the account of his scientific work his biographer in 1846 deals rather cursorily with the discovery which today stands out as his greatest achievement.

And the man behind the discovery—what sort of a person was he? To the present-day observer his portrait

[1] SJÖBERG, S. G., "Vanadium pentoxide dust," *Acta Med. Scand.*, **138**, suppl. 238 (1950).

[2] *Jernkontorets Ann.*, **1**, 6 (1846); JORPES, "Jöns Jacob Berzelius," Fritze's, Stockholm, **1949**; SÖDERBAUM, "Jac. Berzelius," Almqvist & Wicksell, Upsala, **1929**, Vols. I–III; M. E. WEEKS, "Discovery of the elements," J. CHEM. EDUC., Easton, Pa., **1939**, p. 146.

[3] BERGHOLM, *Bergslaget*, **5**, nr. 3, 30 (1950).

drawn by Diez and lithographed by Woelfjle, seems to radiate an exceptionally intense intellectual sharpness. His anonymous biographer in the *Annals of the Corporation of Ironmasters*, however, who evidently knew him intimately, considers that the portrait certainly is "fairly true in details, but the expression of the whole is lacking." According to the same source, he was "of more than ordinary size, and with his towering height and the sincerity of his face, his whole appearance gave the impression of uncommon strength and simplicity. In his later years a marked pallor betrayed permanent ill-health." There may be some suggestion of this ill-health in the features reproduced on the medal which his pupils had made in 1839, when he retired from the Falun Mining School, but on the whole, this picture makes a more impersonal impression than Diez-Woelfjle's portrait, and shows merely the features of a dignified middle-aged gentleman with an aristocratic profile.

His biographer writes that "he was of an honest and upright character, his company was pleasant and highly instructive. He feared no hardships, on the contrary, be loved them, and neither illness nor fatigue could defeat the tenacity of purpose with which he pursued an undertaking. Faithful to his friends, he spoke his mind without mercy, sometimes rigorously, in front of those who did not share his views. This characteristic of his, by which he incurred the displeasure of many men, was bound up with his sincerity. . . ." Whether this obituary was written by an admiring pupil or not, these few words outline a number of traits that one admires in such a man and which also seem to be consistent with the impression one gets from his portrait.

Sefström was born on June 2, 1787, in Ilsbo, Hälsingland, a county in the north of Sweden, where his father was a clergyman. He was sent to a "trivial school" in the town of Hudiksvall, and later to the Gymnasium at Härnösand. In 1809, after a year or two at Upsala University where he also assisted his father "in clerical business," he went to Stockholm, to study physics and chemistry with Berzelius, much to his father's disappointment. For a living he worked as an assistant master in a private school and also as a private tutor. In 1811 Berzelius took him under his charge, and with his usual generosity Berzelius seems to have made himself economically responsible for his further education at Karolinska Institutet in Stockholm. In 1813 Sefström passed the final university examination in medicine and received his doctor's degree in the same year. From 1813 to 1817 he worked as an assistant physician at the Royal Hospital of the Order of the Seraphim, now Serafimerlasarettet, in Stockholm. After 1817, however, he devoted most of his time and interest to chemistry and metallurgy. He was appointed teacher of chemistry at the Royal Military College, "assistant Master of Chemistry at the Royal Caroline Medico-Surgical Institute," and at the Royal Artillery College, from 1818, with letters of appointment as a professor.

When in 1820 the king ordered the establishment of a mining school at Falun, Sefström was appointed chief teacher without having to apply for the post, and, from 1822 when the school opened until 1838 when he was forced to retire because of ill health, he exercised his authority in a manner which his biographer describes as follows: "Those who learnt to know him during this period cannot speak too highly of the zeal, the solicitude, and the inexhaustible energy with which he discharged the duties of this responsible and difficult office. These are qualities that have left deep and lasting traces in the hearts and the work of numerous pupils."

Nils Gabriel Sefström

In 1839 Sefström moved to Stockholm and was made salaried adviser to the Mining Society, director of the "Mineral Cabinet, Laboratorium Chemicum and Library of the Royal Mining College," and "Appointed Member of the Royal Mining College." He also received a number of honorary commissions. Thus, from 1820 he was the editor of *Annals of the Corporation of Ironmasters;* from 1815 he was a member of the Royal Academy of Science and its president from 1840 to 1841.

For many years Sefström was in precarious health, and on November 30, 1845, he died following a stroke.

His discovery of vanadium, by which he, as it were, erected his own monument, literally more durable than copper, is interesting and well known, thanks to the correspondence between him and Berzelius which has been preserved.

In 1801 the Mexican mineralogist del Rio thought

that he had discovered a new metal which he first called erytronium, but which he later considered to be merely lead chromate. Only after Sefström's discovery was it established that del Rio's preparation actually consisted of vanadium.

In 1830, when he was still working at Falun, Sefström believed that he was able to trace the presence of a previously unknown metal in iron from Taberg in Småland. In the beginning the extraction of the new metal was a slow process, on account of the small yield. At one time Sefström nearly gave up in despair, fearing that it would prove to be nothing but chromium after all. From his frequent letters to Berzelius it is clear that the difficulties grew as the investigation proceeded. From the end of 1830 the work was carried out in Berzelius' laboratory in Stockholm. On Christmas Eve, 1830, Berzelius wrote to a friend: "Sefström arrived here yesterday. He is now living with us and will stay until Jan. 12th in order to complete the experiments with his new metal, about which there is no longer any doubt, and of which he has procured good quantities. The experiments in the laboratory were begun already yesterday, and today he has the pots boiling." A few days later he wrote to another pupil: "Sefström has been here since the 23rd. We are working together with his new metal. . . an extraordinary rascal." (Evidently Berzelius referred to the metal.)

In January 1831, thanks to the assistance he received from Berzelius, Sefström was able to remove all impurities in the specimen he had brought with him, and to produce the new oxide in a purified state. As a result, Berzelius could finally establish the discovery of vanadium and in his letters describe its most characteristic properties. Always generous, he ascribed the credit of the discovery entirely to his pupil.

In a letter to his German pupil and friend, Friedrich Wöhler (1800–82), Berzelius writes jokingly about the discovery, alluding to the fact that Wöhler himself had very nearly made the same discovery, but had let the opportunity pass:

> In days of old there lived in the far North a goddess named Vanadis,[4] beautiful and lovable. One day there was a rap at her door. The goddess remained comfortably seated, thinking, "Let them knock again." But nothing more was heard, instead the caller descended the stairs. The goddess became curious and wanted to see who the person might be that did not care whether he was let in or not. She ran to the window and peeped out. "Ah," said she to herself, "it is that rascal Wöhler. Well, it serves him right, he might have shown himself more eager, and he would have been let in. The old rogue, he did not even glance at the window when he left." After some days there was again a rap at the door, and this time the rapping went on and on. At last the goddess went herself and opened the door. Sefström entered, and from that encounter was born Vanadium.

This quotation clearly illustrates the close relationship between Berzelius and his pupils and may well serve as a conclusion to this brief survey of the discovery of vanadium, the man behind the deed, and the subsequent fate of the new metal.

[4] A by-name of the goddess Frigg.

THE IG-NOBLE PRIZE

GRADUATE chemistry students at the Illinois Institute of Technology must watch their test tubes and condensers lest they blunder into winning the weekly "salute to sloppy chemists."

For a conspicuous slip of test tube technique, any graduate student in the department may qualify as "an outstanding contributor to the retrogression of the science of science."

Students recently cited for lack of achievement in the laboratory have attained recognition through devious means. For instance, one scholarly chemist ran the timer with the switch off. Another demolished a gas buret with his bare hands, while a fellow lab man discovered the failure of mercury thermometers at extremely high temperature. Others have learned the tragedy of substituting flywheels for pinch clamps or for submitting conclusions before converting thermometer scales.

To urge candidates for master's and doctor's degrees to a more careful coddling of complex chemistry gear, students themselves have authorized a public spanking for careless classmates. The official whipping consists of a student presentation of two 4-inch glass-coupled tubes, resembling something out of an alchemist's secret cupboard. It is appropriately dubbed "The Ig-Noble Prize."

GRADUATE INORGANIC CHEMISTRY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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In connection with the informative series of articles and symposia which have appeared during the last few years in This Journal (See, *e. g., 1–4, 7, 10–12*) dealing with methods of instruction and research activities in the different fields of chemistry at various institutions, the following account of the program of graduate study and research in inorganic chemistry at the Massachusetts Institute of Technology may be of interest.

In 1930 Professor F. G. Keyes, then Chairman of the Department of Chemistry at the Massachusetts Institute of Technology, authorized the allocation of space and funds for the establishment of a Research Laboratory of Inorganic Chemistry, which was to operate jointly with the Research Laboratories of Organic and of Physical Chemistry and whose function it was to facilitate and encourage investigation in the field of inorganic research, which had been somewhat neglected in recent times. The Massachusetts Institute of Technology was thus one of the first institutions to recognize the need of bringing attention to the desirability of fostering research in this oldest branch of chemical science.

In the intervening twenty years the program of graduate training in inorganic chemistry leading to the doctor's degree in this field has continued unbroken, and about 140 publications have resulted from the activities of the group of staff and students engaged in this work. Some 54 Ph.D. or D.Sc. degrees have been awarded during this score of years, together with a small number of Master's degrees.

In the last few years increased interest in the field of nuclear chemistry, or radiochemistry, has resulted in the consolidation with the inorganic group of several staff members and their students engaged in the study of nuclear phenomena. A curriculum of courses and a list of other requirements for the doctorate have been worked out whereby those engaged in either aspect of the joint inorganic and nuclear field of interest attend classes, seminars, and research conferences held in common, and pass the same major examinations and meet other requirements for the degree in a similar fashion.

The course of graduate study contains an introductory review of inorganic chemistry at a level more advanced than that found in the usual undergraduate courses in this subject. Emphasis is on generalization of the vast amount of factual material which confronts the neophyte in this branch of chemistry. The structural aspects of the subject are properly given considerable attention as revealed by the expanding knowledge acquired in recent years through the application of X-ray and electron diffraction techniques and the interpretation of the data furnished by infrared and Raman spectroscopy. The reference books used include, among others, Ephraim (*5*), Hückel (*6*), Sidgwick (*9*), and Wells (*13*).

A course in advanced structural chemistry is also provided, which treats of the interatomic forces which lead to the formation of molecular aggregates, including one-, two-, and three-electron bonds and multiple bonds; hydrogen and metallic bonds; van der Waals forces; resonance; ionic character and electronegativity; and other topics, based largely upon the development of these ideas presented by Pauling (*8*). Methods of determining molecular structure and the interpretation of chemical properties in terms of structural considerations are also discussed.

Advanced inorganic laboratory practice is provided early in the graduate student's program, wherein a choice is given in the repetition of some published piece of inorganic research selected from a list of suitable journal articles or other sources. In this course practice is acquired, for example, in the manipulation of closed systems under high vacuum conditions; in reactions carried out in nonaqueous solvents, such as liquid ammonia; and in operations at both high and at low temperatures. The synthesis of compounds of the less familiar elements not only provides a familiarity with the chemistry of these elements but also, by proper selection of the assigned problem, furnishes valuable training in laboratory procedure and practice, which proves to be of value when the student undertakes his own doctor's thesis.

An introduction to the techniques of preparation and measurement of the radioactive elements is provided by a course in radiochemistry, which may be taken together with, or independent of, a laboratory course in the same field. The laboratory work covers such topics as radiochemical analysis, the fission process, and a variety of nuclear reactions.

One of the subjects included in the list of graduate courses required for inorganic majors, which has proved to be most profitable, is a course entitled "Special Topics in Inorganic Chemistry," which is offered in alternate semesters with a journal meeting or seminar in inorganic chemistry. In the special topics course for the first five weeks, members of the staff and invited guest speakers from other departments or other in-

stitutions give a series of talks. General discussion by the students and staff members attending is encouraged. The subjects to be discussed are posted in advance and a brief summary or outline of the talk is distributed by the speaker in mimeographed form at the time of his lecture. The necessity for note taking is thereby reduced to a minimum, with more opportunity for listening and for questioning. For the rest of the term the students registered for the course take turns at presenting an account of an approved topic. Occasionally, half a period may be devoted to a talk delivered in French or German, an outline of which has been provided prior to the talk. The program of this course is varied from year to year, as, of course, is the content of the journal meeting or seminar. The latter course is limited to one class hour per week and the topics presented are in general of somewhat smaller scope than those offered in the special topics course.

After one or more terms in residence the candidate is required to pass a written qualifying examination consisting of three parts: inorganic and analytical, organic, and physical chemistry. This examination is posed at the level corresponding to the middle of the senior year of the M.I.T. undergraduate curriculum in chemistry but is not based solely on the content of the courses as offered at this Institute.

Research is begun by the student usually after a term in residence. He is encouraged to look about the laboratories, to talk with the various instructors who may act as his supervisor, and thereby to make a more intelligent choice of a subject for his experimental problem than might otherwise be possible.

After he has selected his supervisor and a topic for investigation, a committee of at least five members is named, consisting of staff members selected from his own field of research as well as from the other three fields (physical, organic, and analytical) the function of which is to provide a critical evaluation of the candidate's performance in research from the respective points of view of the several committee members. This committee system of supervision has proved to be of definite merit and has justified the time which is necessarily required for its proper functioning. The conduct of the final examination on the candidate's thesis and the decision regarding its acceptance for the degree are placed in the hands of the thesis committee.

The research program in inorganic chemistry is of a diversified character, the widest latitude being given in the choice of a problem, so long as it possesses relevance to the inorganic field and offers the possibility of a significant contribution to the chemical literature. The isolation and study of numerous inorganic compounds, often of the less familiar elements, and the elaboration of the chemistry of some of the commoner elements have both received attention among the subjects of investigation. The preparative side of this branch of the science has been stressed from the beginning, as it was felt that the primary function of the inorganic chemist is the study of the best methods of preparation of substances in a reasonably pure state.

Until the last few years the analytical aspects of inorganic research were included in the research program of this field, since nearly every problem in preparative chemistry involves in one way or another the corroborative evidence of analytical chemistry in establishing the conclusions sought in the solution of the problem. At the present time a separate curriculum and degree in analytical chemistry are offered for those who desire to specialize in this branch of chemistry.

In the construction of apparatus needed for the student's research, he has the facilities of the Department's shops and glass blower at his disposal for the more difficult operations; but he is encouraged to perform for himself as much of this construction as his capabilities permit with the aid of the laboratory's supply of tools and equipment. Throughout his training the accent is upon the development of the student's self-reliance, initiative, and originality.

A few of the subjects of investigation with which the inorganic group is currently engaged include: the lower valence compounds of niobium; the Walden inversion of complex cobalt compounds; the preparation and properties of volatile fluorides in Groups IV, V, and VI; and the stabilization of hydrogen peroxide solutions.

In addition to research in the nuclear field, which has been described elsewhere (*4*), a number of inorganic doctorate theses have been carried out with joint participation in the supervision of the problems by members of other departments, such as metallurgy, physics, or electrical engineering. This liason of research programs in the borderlands between the sciences has proved to be a source of interest and stimulation to the students engaged therein.

With the generally recognized increased importance of inorganic research since the last World War, the demand for trained graduates in this field has increased and at the present time the supply of suitable inorganic Ph.D.'s falls considerably short of the demand.

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THE USE OF UNWEIGHED IRON WIRE AS A PRIMARY STANDARD

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THE use of weighed portions of iron wire as a primary standard for the standardization of potassium permanganate and other oxidizing agents may be found in practically any elementary textbook of quantitative analysis. The authors of this paper, while working with samples of iron wire, were surprised to find that the diameter of the wire was extremely constant. This finding suggested the use of measured lengths of wire in place of weighed amounts as a primary standard.

A very simple method was devised for cutting the iron wire. A Hoffmann screw clamp was attached to one end of a meter stick and the wire held firmly by means of the clamp. The wire was then stretched to the desired length and cut by scissors. The samples were then rolled in a small coil and weighed.

Table 1 shows the agreement in weights and analysis of different lengths of wire, 9 mils in diameter. The results of the analysis for iron content of the different samples are included in the table to show the constancy of purity of the particular spool of iron wire used for these experiments.

TABLE 1
Analysis of Measured Lengths of Cut Iron Wire

Length, cm.	*Weight, g.*	*Fe, %*
50	0.1586	99.66
50	0.1589	99.45
100	0.3170	99.55
100	0.3172	99.31
75	0.2380	99.34
75	0.2380	99.45
75	0.2382	99.34
75	0.2379	99.25
75	0.2382	99.18
	Average	99.34% ± 00.11

To show further the agreement between length and weight of the cut iron wire four different 75-cm. lengths were cut and weighed by three persons at different times.

Six samples of iron wire 14 mils in diameter were also cut in 5-cm. lengths and weighed. Even with such short lengths of wire the precision of the weighings was still within acceptable limits for many types of quantitative work.

TABLE 2
Results of Weighing 75-cm. Lengths of Iron Wire Cut by Three Individuals

A Weight, g.	*B Weight, g.*	*C Weight, g.*
0.2381	0.2383	0.2381
0.2380	0.2380	0.2380
0.2381	0.2380	0.2382
0.2383	0.2382	0.2381
0.2381 Average	0.2381 Average	0.2381 Average

Average deviation, 0.43 part per thousand.

TABLE 3
Results of Weighing Six 5-cm. Lengths of 14-mils Iron Wire

Weight, g.	*Weight, g.*
0.0389	0.0389
0.0390	0.0388
0.0387	0.0387

Average deviation, 2.6 parts per thousand.

Experimental results have shown the feasibility of preparing iron standards from iron wire by cutting desired lengths after initially determining the assay or the density. If the iron wire is sufficiently pure, as shown by the manufacturer's assay, only one weighing is necessary to establish the relation between the lengths to be cut thereafter to obtain known standards. This has the obvious advantage of eliminating time-consuming weighings as well as titrations. Where time is a factor this method should have very practical use. Weighings and titrations could be abolished completely if information as to the exact assay, density, and diameter were given by the manufacturer.

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THE PLACE OF THE SCIENTIFIC METHOD IN THE FIRST COURSE IN CHEMISTRY[1]

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THE extensive analysis of college curricula and course content in recent years has focused a great deal of attention on the obligation of science teachers toward the student who does not anticipate a career in science. This priming of the pedagogic pump has produced a type of course the avowed purpose of which, to borrow Conant's phrase, is to develop an awareness of the "tactics and strategy of science."[2] The almost inevitable consequence of this emphasis has been to point the course content toward learning *about* science and to relegate the less intriguing, philosophically mundane factual information to a secondary position. Generally speaking, such a course is not taken by the student who expects to enroll in advanced science courses. He rather takes the more traditional course which may well be designated as his first course toward a Ph.D. in chemistry. This conference is concerned with the problems of teaching this future member of the chemical profession. It is the purpose of the present discussion to focus attention on the problem of helping him to see with equal clarity the development of the "tactics and strategy of science." It is a problem which cannot be solved by sacrificing large amounts of the necessary factual information usually included in the first chemistry course.

An apt subtitle for this discussion is: "Let's Put the Horse Before the Cart." The "horse" is an awareness of that habit of thinking, the modus operandi of the practicing scientist glorified by the term, "the scientific method." The "cart" is the informational content of the first course in chemistry, either high school or college. The twisting of the familiar cliché implies that the "horse" is not always where he belongs; the "cart" then loses mobility and bogs down under the weight of an ever-increasing load of chemical facts. The pedagogic puzzle in this situation arises from the rate at which scientific progress discovers new facts. The "natural philosophy" courses of two generations ago have been replaced by a variety of scientific specialties. Teachers are forced to present and students to assimilate so much chemical information that there is no time for formal philosophical or historical lectures.

WHAT SHOULD THE FIRST COURSE ACCOMPLISH?

To call this course a first course toward a Ph.D. in chemistry is neither a condemnation nor an hallucination. The singleness of purpose does not imply an elimination of its cultural value either for the eventual Ph.D. or for the student for whom it is the only exposure to science. Just as the introduction to a language is crucial to its mastery, it is of equal importance that the first course in chemistry supply the embryonic chemist with an ample vocabulary of chemical facts and grammar of chemical theory to make him sufficiently literate for later courses in the science. It is equally important that such a student should not be left to his own devices to discover what the methods of science are. The beginning course for the Ph.D. should develop in him an awareness of the scientific method and its power. He should be helped to recognize how the collective efforts of scientists throughout the ages developed it. Moreover, his familiarity with it must exceed an historical perspective. He must recognize it when he sees it applied to mid-twentieth century chemical problems. He should habitually use it as a method of attack on his own chemical problems and look to it as at least one line of attack on all his problems. Eventually it should be hoped that his appreciation of it would approach a maturity which would let him see its limitations and possibly the boundaries which experience as well as philosophical logic places upon its applicability.

How then is this appreciation of the scientific method to be achieved? It certainly requires a recognition of its importance by the teacher. He must not rush from what Barzun[3] bitingly describes as his "Ivory Lab" to an equally "Ivory Classroom." Covering ground must not be done at such a rate that perspective is lost. He probably gets little assistance from the student's text. Of eight recent newly written or revised college texts for the first course, bulkily averaging 700 pages of material, only one allotted more than a few brief paragraphs to a treatment of the scientific method. Nor is it sufficient to present a stepwise outline of the scientific method in the initial "bull-session" lecture before serious work has begun and then never to mention it again. If the student is to recognize and appreciate the scientific habit of mind he must never be allowed to take it for granted. He should subtly but constantly be made aware of its illustration by the whole of the course content. This implies that the teacher should be ready with a sentence or two of

[1] Presented before the Conference on the Teaching of Chemistry at Michigan State College, August 22–25, 1950.

[2] CONANT, JAMES B., "On Understanding Science," Yale University Press, New Haven, Connecticut, 1947, p. 1.

[3] BARZUN, JACQUES, "The Teacher in America," Little Brown & Co., Boston, 1945, Chap. 7.

timely comment to emphasize the relationship between a specific fact and the method of investigation which has led to its discovery. The point of view of the course should be one in which the "horse" is where he belongs, in front of the "cart." The following suggestions are aimed at pointing out some of the nuances which can be established in the fact-full course without spending undue time on "history" and "philosophy."

PRECISION IN THE USE OF LANGUAGE

The first emphasis which a student should recognize as typical of the methods of physical science is the insistence on precision in the use of language. This is a technique which must be adopted by the student himself before he possibly can be successful at learning science. The beginning student must learn immediately to say what he means. Drastic downgrading should follow his saying "mix" when he means "react" or "element" when he means "pure substance." In the same manner that high-school chemistry often constitutes a student's first applied mathematics it also often represents his initial experience with the precision of technical language.

Another equally important primary consideration is for the student to realize the care with which the physical scientist defines the concepts to which he assigns convenient terms. "Atom" and "molecule" are unequivocal terms and have a very real meaning. Usually the student fails to realize that they have been invented by the scientist as an "idea vocabulary" for his theories. They are what Northrop[4] calls "concepts by postulation." Their usefulness in correlating the vast amount of observation which scientists make depends upon the precision with which the postulates have been constructed. Photographs only recently taken by the electron microscope have begun to reveal visual evidence of molecules. Nevertheless, "molecule," invented to make theory consistent with chemists' laboratory observations, has been in prolific use for more than a century and a half. It comes as no surprise that it is beginning to be possible to "see" them.

DEFINITION OF CONCEPTS

A second primary consideration should be to help the student early in the course to make his own definitions of science and the scientific method as a background against which the course content can unfold. The following may serve as suggestions. Conant[5] emphasizes the dynamic aspect of science by commenting: "Science emerges from the other progressive activities of man to the extent that new concepts arise from experiments and observations, and the new concepts in turn lead to further experiments and observations." The homelier definitions: ". . .deduction and induction playing leapfrog" or ". . .a club sandwich of hypothesis and experiment" say the same thing. Einstein's[6] philosophical polysyllables awe a bit at first, but stimulate thought: "Science is the attempt to make the chaotic diversity of our sense experience correspond to a logically uniform system of thought. In this system single experiences must be correlated with the theoretic structure in such a way that the resulting coordination is unique and convincing." Many a beginning student's coordination lacks little in uniqueness; yet he must learn to make it convincing. It is likewise a help to the student to have a stepwise outline of the scientific method for a pattern. Such should be presented only with illustrative comment to emphasize its flexibility and adaptability. As the course proceeds, reference back to such an outline can be very meaningful. After a problem is recognized (Step 1) the observation of data is begun (Step 2). The observation may or may not be made more efficient by some directive hypothesis (a guess as to "Why?"). Quite frequently a scientist turns up a law from his data (Step 3). Students should appreciate that a law is an efficient, or possibly lazy man's tool. It relieves him from having to make burdensome experiment, especially if the law is quantitative. It is merely a statement of the way in which nature operates. The lazy intellect is content at this stage; the scientific mind immediately seeks an explanation of why nature operates so. His hypothesis (Step 4) usually involves some invented concepts which can be verified only by recourse to further experimentation, often outside the realm covered by his previously discovered law (Step 5). Frequently this thorough scrubbing of an hypothesis by experiment wears it away or exposes such defects that it is useless. If it outlasts such treatment or, as may be the case, it actually grows in stature it receives the compliment of being called a theory (Step 6). It should not be overlooked that the scientist invariably reserves the right to revoke such a designation. He may modify the theory on the basis of new evidence or he may discard it entirely. Such discarding starts the quest again, possibly with the previously discovered law which has not been invalidated by the unsuccessful attempt at explanation.

ORDER OF PRESENTATION

A third concern of the teacher should be to give careful attention to the order in which the factual information of the course is presented. This is not to say that the organization should strictly conform to the chronology of chemical history. It means rather that the student should be allowed to make some of the same analyses of the information which resulted in the conclusions reached by the early investigators. A probable consequence will be that what appears incidentally to be history actually will be much more meaningful than mere chronology. In general it should be observed that laws came before theories. It is a mistake for the student to read seven carefully listed statements embodying Dalton's Atomic Theory

[4] NORTHROP, F. S. C., "The Logic of the Sciences and Humanities," The Macmillan Co., New York, 1947, p. 139.

[5] CONANT, JAMES B., *op. cit.*, p. 24.

[6] EINSTEIN, ALBERT, *Science*, 91, 487 (1940).

and then to have the text suggest, "Let us now turn our attention to the evidence." Such a procedure completely by-passes for the student any opportunity to duplicate in his own thinking the asking of the crucial "Why?" It also seems only right that the beginning student should be given the benefit of seeing simple weight ratios evolve into the Law of Definite Proportions. To introduce this concept by the illustration, "18.016 grams of water contain 16.000 grams of oxygen plus 2.016 grams of hydrogen," immediately causes him to be suspicious of the peculiar choice of numbers. He either expects something very complicated to emerge from such obviously trumped-up figures, or else he keeps waiting for the teacher to reach back into the hat for another rabbit. It will be some time before atomic weights will be more than magical numbers chosen to give the right answer for the student who uses them to begin his study of chemical combination.

Another misordering of information often occurs in the teaching of the ionization concept. The evidence: abnormal colligative properties, the phenomenon of electrolytic conduction, Faraday's Laws, instantaneous reactions in aqueous solution, etc., should suggestively challenge the student to frame his own explanation. To present the Arrhenius Theory first allows the student to look upon "dissocation" as the phenomenon, instead of letting him recognize it as an idea introduced to explain the observed phenomena. Later the "ion atmosphere" of the Debye-Hückel Theory appears to him to be a contradictory phenomenon. He loses sight of the fact that it is rather a postulate of a different theory, based on additional, not contradictory evidence.

This concern with order in the course content is particularly important in the alignment of laboratory and classroom work. It is an insult to the label "science laboratory" to make it possible for an efficient, forward-looking student to enter the laboratory with all the questions in the manual answered out of the text or as a consequence of classroom discussion. Allowance must be made at least occasionally for the apparent inefficiency of real experimentation in an unexplored area. All who have engaged in research know how much time is spent on the wrong track. The appreciation of this is denied the beginning scientist who is forced rigidly along a prescribed path to a solution in two or three hours time. Chemistry is fortunate in being able to emphasize the problem aspect of experimentation by the use of "unknowns." However, many of the traditional experiments, upon critical examination, turn out to be mere manipulation toward a foregone conclusion. For example, the verification of Charles' Law in the elementary laboratory is really rather farcical, especially if it is scheduled after the topic has been discussed in class. The student knows the law. Likewise he knows that experiments with much more accurate equipment than that available for his own use have verified it. If, however, the problem is given him of determining the absolute zero of temperature, he is immediately forced to begin some truly scientific thinking. Even though he may anticipate that the manipulations will be the same as for the Charles' Law verification, the required analysis of his data is likely to be a fresh experience.

PRESENT-DAY PROBLEMS

A fourth suggestion is that the teacher choose appropriate subject matter so that some emphasis can be placed on the working of the scientific method toward the solution of current chemical problems. This view has been stated most ably by Professor Hildebrand[7]: "The story of a scientific idea is far more exciting if it leads up to the present, into explorations still going on. . . ." The attainment of an historical perspective does not mean that the student needs only to stand with Lavoisier and look backward to the first inquisitive man. It must include the realization that science's current solutions to nature's puzzles are provisional at best. An example can be drawn from the whole attack on the problem of the chemical nature of matter. More than half a century of experimentation based on Dalton's Atomic Theory made possible Mendeleev's Periodic Law. This powerful generalization, along with the cases in which nature refused to conform (Co and Ni, Te and I), virtually demanded some explanation in terms of the structure of the atom. Physics supplied both the concepts and the techniques which eventually led to Rutherford's and Bohr's giving the chemist a theoretical "working model" of the atom. Although this is a far better hypothesis than was the phlogiston explanation of burning, yet it similarly has had to be modified in the light of more recent information. It may be said that chemistry now finds itself at a stage in the investigation where a veritable coalescence of theories is imminent. "Chemical" and "physical" properties of matter are losing their distinction as both find explanation in terms of chemical geometry, size, electron distribution, nuclear constitution, etc. The usefulness of the setheoretical generalizations will be tested just as have all the others of ages past. They must predict as well as correlate and broaden our understanding of the same puzzles of nature which received a partial solution with Dalton's early nineteenth century theory. It might be noted in passing that the prerogative to guess wrong has not been confined to the early investigators. Their mistakes always seem obvious to the 1950 student, provided as he is with so much more modern data. He should be reminded, for instance, that only in the last few years has the reclassifying of the elements of highest atomic number into an actinide series corrected a mistake which still adorns many chemistry classroom walls in the form of the pre-1947 periodic tables.

In addition to the psychological advantage of active student interest in present-day chemical developments there is also a point to be made for the pedagogic efficiency of choosing such illustrative information. Among the many examples of this, the story of Nylon's development demonstrates how one set of facts can serve a multiple purpose. It can be used to introduce

[7] HILDEBRAND, J. H., J. CHEM. EDUC., **26**, 450 (1949).

the beginning student to the topic of esterification, the analogous amide formation, condensation polymerization, and the peptide linkage typical of protein structure. It need not be presented as a complicated bit of chemical magic but as a straightforward series of experimental attempts to follow what are basically "common sense" hypotheses. The student not only gains an appreciation of how science operates, albeit with the resources of the du Pont Company at its disposal, but he gains confidence in his ability to substitute scientific understanding for nonscientific awe of the products of present-day technology.

CONCLUSION

It is obvious that space does not allow the extending of this list of suggestions to include all of the pertinent emphases which are part of any attempt to establish a full recognition of how the scientific method operates. It is hoped, however, that those presented may serve to support the analogy that there is a "horse" and a "cart" aspect to the present fact-full beginning course in chemistry at both the high-school and the college level. The teacher is serving science best when he keeps the "horse" where he belongs, ahead of the "cart," and helps future chemists to realize it.

AN IMPROVED MELTING POINT APPARATUS

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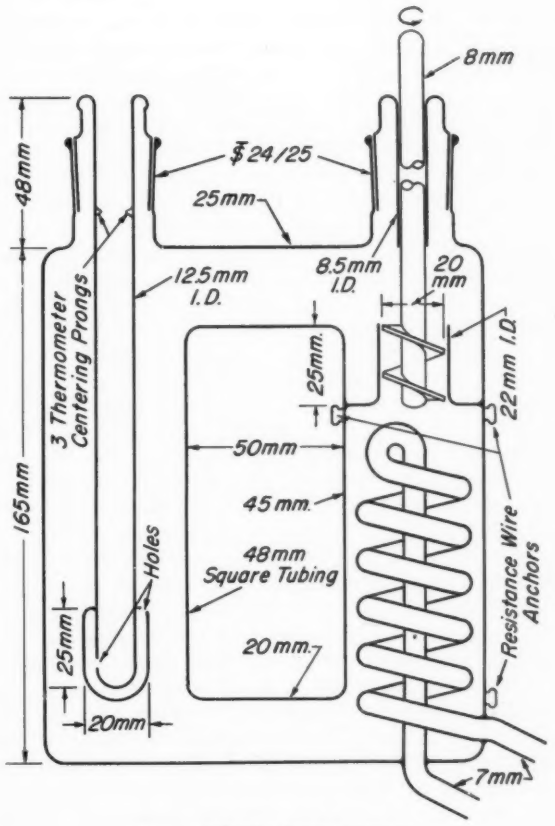
AN IMPROVED form of the Hershberg precision melting point apparatus[1] that has given very satisfactory service for five years is described herein.

Several advantages of the improved melting point apparatus are evident from the figure. The double-walled construction of the thermometer well minimizes possible temperature surges. The Anschutz thermometer rests on the bottom of the well and is automatically centered, leaving ample space for several melting point tubes. Use of square tubing (Fischer and Porter Company, Hatboro, Pennsylvania) for the thermowell leg of the apparatus permits better observation by avoiding optical distortion effects. A helical stirrer rotated in a close-fitting collar gives positive circulation of the heat transfer medium. External electrical heating makes possible the use of various heat-transfer media, either electrolytes or nonelectrolytes. Silicone fluid (Dow-Corning, Type 550, 112 centistokes viscosity at 25°C.) was found to be very satisfactory. The tubular helical coil within the heating leg permits rapid cooling with a stream of air, and it may also be used for cooling the heat transfer fluid for low temperature operation by circulating a cooling medium through it.

The heating element comprises about 13 feet of No. 28 B. and S. gage resistance wire (4.07 ohms per foot) wrapped as a noninductive winding on the heating leg with the middle of the wire looped around the lower anchor and the two ends attached to the upper wire anchors. The individual turns are separated by asbestos cord and the whole is insulated with asbestos cloth tape. The heat input is controlled by means of an autotransformer, adjustable from 0 to 135 volts.

Suitable melting point tubes (*ca.* 8 inches long) are readily prepared from commercial thin-walled capillary tubing of 1.5–2.0 mm. diameter (Kimble Glass, Toledo, Ohio).



Improved Melting Point Apparatus

[1] HERSHBERG, E. B., *Ind. Eng. Chem., Anal. Ed.*, **8**, 312 (1936).

THE ROLE OF CHANCE IN CHEMICAL DISCOVERIES

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THE GREAT CHANCE DISCOVERIES

Beginning with one of the greatest discoveries of all times, the kindling of fire, chance has paved the way for many important stages in chemical history arising from fundamental but unexpected discoveries. Pertinent examples are the unrecorded accidental discovery of fermentation and acetic acid, the raising of bread and fermentation by yeast, the production of metals by reduction, the preparation of glass, tanning and dyeing (with use of alum, vitriols, plant juices, etc.), brewing, alcohol distillation, the preparation of mineral acids by dry distillation, the propelling power or explosive action of combustible mixtures (gunpowder), etc., etc. Later (1649), J. R. Glauber found that coal can be broken down; that the liquid resulting from its dry distillation can be separated into a low- and a high-boiling fraction. J. J. Becher discovered the "philosophical light" (illuminating gas, 1680), Michael Faraday discovered benzene in the liquid which condensed from illuminating gas when strongly cooled (1825), and F. F. Runge found carbolic acid and the tar bases by distillation of Glauber's high-boiling tar fractions (1835 ff.). At about this same time Friedrich Wöhler made his fundamental chance discovery, the synthesis of urea (1828), and thus involuntarily furnished the proof that the chemist, with his methods and inanimate materials, is able to prepare synthetically materials whose production had hitherto been supposed to be a special prerogative of living organisms. It was Liebig who, from 1837 on, prophetically predicted that future chemists would be able to produce in their laboratories all natural organic substances such as "the brilliant coloring matter of madder or beneficial quinine." In view of their subsequent development, Wöhler's synthesis and the firm conviction of Liebig can be regarded as a realization of the alchemical goal of the artificial production of gold, even though the latter was concerned with only the metals, while this modern advance was on the higher plane of mental creativeness, even in the province of animate nature. Accordingly, the 18-year old W. H. Perkin, who had been thoroughly convinced of the feasibility of such predicted chemical syntheses, was not afraid to make attempts along these lines and discovered by chance a new industrial continent (1856). He accidentally produced the dye "mauve" from the tar bases and thus took the first steps in the creation of the gigantic chemical industry of artificial dyes, drugs, etc. Similarly, the enticing picture of chemical synthesis led to the accidental discovery of the important drug antipyrine by the 24-year-old Ludwig Knorr (1883).

The following instances are selected from the multitude of discoveries that bear the mark of chance: gas adsorption by finely divided charcoal (C. W. Scheele, 1773), catalysis by acidic ions (ester-formation, Scheele, 1781), saccharification of starch (Kirchhoff, 1811), selective heterogeneous catalysis [dehydration of alcohol by alumina, Deimann, *et al.*, 1795; H. Davy's studies of the ignition of combustible gases on a hot platinum wire, 1816; Thenard's discovery of the decomposition of hydrogen peroxide by finely divided metals, 1818], the discovery of oxygen by Scheele and Priestley (1769–74) and its liquefaction by Pictet and Cailletet (1877), the anaesthetic action of laughing gas by Davy (1799), the phenol antisepsis by J. Lister (1867), the soporific sulfonal by E. Baumann (1884), and the inorganic "traces" and the organic "active materials" of the recent past.

In the theoretical field, the chance discoveries include: isomorphism by E. Mitscherlich (1818), isomerism (Liebig-Wöhler, 1822–23), the first heat theory by J. R. Mayer (1842), the resolution of racemic compounds by L. Pasteur (1848 ff.), the asymmetric carbon atom (stereochemistry, J. H. van't Hoff, A. Le Bel, 1874), the benzene theory (A. Kekulé, 1865), the noble gases (Rayleigh-Ramsay, 1894 ff.), the X-rays (W. Röntgen, 1895), the Becquerel rays (1896), the fission of uranium (O. Hahn, *et al.*, 1939).

What now is or should be the attitude of the reflective scientist and investigator toward chance?

HISTORY OF CHANCE IN INVENTIVE ACTIVITY

The history of chemistry (particularly in the nineteenth and twentieth centuries) consists essentially of a description of the hundreds of thousands of successive discoveries of new chemical substances, their properties, and applications. The historical account reports the pertinent facts about the materials and their discoverers and thus satisfies the practical needs of our contemporary readers. However, every important discovery can be likened to a drama consisting of a series of acts; it is also intimately connected with the personality of the discoverer and presumes an understanding public. This type of historical treatment does not clarify the primary element—a psychological-transcendental problem complex—namely, the origin of the discovery. For the poet, the following rule was formulated by

Goethe: "The question where did the poet obtain it concerns itself only with the substance, but it enlightens no one as to how he achieved his result." The "whence" and the "how" lead to the spiritual-mental roots, from which the "it" matures. Discoverer and poet usually pass over these questions in silence, either because they created the "it" (*i. e.*, the discovery) involuntarily or without accounting for it to themselves, or since they deliberately omitted reporting on the previous history, because of a certain reluctance to give a public disclosure and analysis of the whole mysterious process. An attempt to arrive at even a partial clarification of the internal and external factors which play a part in such achievements may be of value, especially in the present period when so much of the world is impoverished and under stress, *i. e.*, when a large part of humanity is in need of new discoveries and inventions that may lighten the burden of daily life.

From the standpoint of ethnopsychology it is important to note that the Greeks, a mentally eminent people, put the intellectual creativeness of man into an extrahuman sphere, and ascribed it not merely to the influence of superhuman vital forces, but regarded it as the direct manifestation of such forces, namely as a gift of the Muses. Even Homer entreated the Muses to grant him poetic inspiration and factual knowledge for the description of his heroes and their heroic voyages. As goddesses of the arts and sciences the Muses occupied a place of high honor in the philosophical schools of Pythagoras and Plato, and even Virgil (first century A.D.) called on them as dispensers of the knowledge and understanding of cosmic laws.

This ancient conception of the transcendental origin of human knowledge is documented in the mythological figures of Prometheus, Hephaestus, Talos, Daedalus, etc., who as Titans and sons of the gods discovered or invented fire and fire-making, pottery, the wheel, the production of metals, the art of forging, the preparation of glass, dyeing, etc., and thus founded our material culture. Man as "discoverer" or "inventor" functioned only as the tool and agent of divine benevolence. This special character of inventions and discoveries was openly expressed when, for instance, Pythagoras sacrificed one hundred oxen to the gods as propitiation and thanks for the law which he discovered. When highly talented young men died at an early age it was usual to say that "they had fallen as sacrifices to the envy of the gods."

The Egyptian-Roman neoplatonist Plotinus declared: "It is the business of the gods to come to me, not mine to go to the gods." This holds in general for accidental discoveries; they must come to us voluntarily. Experience has taught that "these gifts of the Muses" carry an element of singularity, irregularity, and irrationality; they lie beyond the range of human will and planning, with respect not only to the time of their appearance and the kind and number of the discoveries but also with respect to the character of the discoverer. These factors constitute the element of luck or chance. Accordingly, the Greeks devised the goddess Tyche to preside over chance and luck; the evolutional reaction of mankind was thought to be determined and guided by her interference in human affairs. However, the powerful voice of the great atomist and atheist Democritus (fifth century B.C.) was early raised against such notions. He declared that men had created for themselves a delusive picture of chance as a cloak to cover their own perplexity, even though every event in world affairs is fixed by the mechanics of the atoms, their shapes and motions. But was not he himself forced to make use of chance when he assumed that the deflecting action of an impact had produced his chaos from atoms which originally vibrated in parallel paths? Centuries later, Immanuel Kant baldly characterized this unsupported assumption of Democritus as a piece of shamelessness.

The Middle Ages remained a favorable domain for the Greek and Aristotelian natural philosophy, and their great advocates looked on research and discovery as spiritual actions which occurred in a closer communion with God. Among these mystics, the monk Raymundus Lullus (1235–1315) enjoyed a special popularity because of his *ars magna*, which taught that all problems in theory and practice could be solved by a mechanical automatic thought apparatus. If various materials or arbitrarily chosen concepts were represented by rings which could be rotated around a common axis, then such revolutions could produce the most varied combinations of the ideas and perhaps, by mere chance, some of these combinations might prove to be useful discoveries, in other words we have here a speculative *ars inventiva*.

The introduction of inductive research in the new era was followed by a turning away from the speculative method, particularly after Francis Bacon (1561–1626), who advocated experimentation and systematization of experimental facts as the most reliable foundations of science, especially natural science: "There remains simple experience, which, if taken as it comes, is called accident, if sought for, experiment. But this kind of experience is no better than a broom without its band, as the saying is, a mere groping, as of men in the dark that feel all round them for the chance of finding their way, when they had much better wait for daylight, or light a candle, and then go." Certainly one of such fixed goals was formulated in his expressions: "*Scientia est potentia*" and "might or power brings usefulness." By setting up tables for a systematic experimental study according to preconceived ideas, he tried to eliminate chance and to construct a "technique of invention." But like the Lullian attempt of more than three centuries earlier, the Baconian effort also remained of no significance for experimental study. Conditions seem to be different in the theoretical field, when, for example, it is a matter of the synthesizing of concepts. The great Laplace (1749–1827) in his turn, commented: "The essence of invention lies in bringing together assemblable facts which had previously 'stood apart.'" In his commemorative address for von Tschirnhaus

(the inventor of porcelain) Fontenelle declared to the Paris Académie (1709): "A first discoverer finds a secret ordinarily by chance, but a second, who searches for what the other has found, can hardly find it other than by meditation." The well-considered search and systematic experimentation along a given line which has already been laid down is certainly the most successful road to discovery even today; an active imagination and combining talent can smooth this path.

Joseph Priestley (1733–1804), the brilliant discoverer of new gases, sought, in his own manner, to make contacts with "chance," without preconceived ideas and objectives. He compared his method with that of a hunter who, hoping for a good bag, goes out into the woods and fields, not knowing where and what sort of game he may flush, but he proceeds in good spirits and with keen senses. Concerning "chance" Priestley wrote: "We owe more to chance, *i. e.*, philosophically speaking, to the observation of facts arising from unknown causes than to our own scheme of preconceived theories." Justus Liebig (1830–72) who had many brilliant discoveries to his credit, likewise proceeded confidently when he advised: "If one only works, he is always sure to make discoveries no matter where he starts." Therefore "chance" is the bringer of discoveries. Chance, as an integral element of the creative human mind, includes the quality of originality and that which acts above or beyond the assumed order. "Necessity and law, on one hand, and chance and freedom, on the other, are admittedly opposed, but opposites are not mutually exclusive but supplement each other." Thus argued Julius Robert Mayer (1814–78), the discoverer of the mechanical equivalence of heat. He continued: "Two kinds of causes must be distinguished, the first in which the causes actually correspond to the effects, the others in which the causes merely initiate the action." In such latter cases "great oaks from little acorns grow." It may now be stated that in the field of the great mental creations—not only scientific discoveries—chance plays the role of the natural "initiator." It provides both the most suitable circumstances and the most effective combinations of ideas, but it must be recognized opportunely and turned to advantage.

Chance acts as initiator in the fate of the individual as well as in the history of humanity—the historians refer to it also as a "good servant." In the natural sciences it functions as the "grand promoteur des nouveautés physiques," according to the distinguished discoverer J. B. Biot (1774–1862). Certainly, his discovery of the optical rotatory power of amorphous organic materials (1815 ff.) was accidental. Modern atomic physics defines chance as follows: "The accidental. . .in the sense of the physicist. . .is the incalculable stroke, so to speak the acausal atomic act, which through an amplifying effect makes itself evident into the macrophysical" (E. Buchwald, 1945). Likewise, in the theories of modern science, in the bold attempts to solve the most significant problems—as once with the ancient Democritus—chance plays the role of a mental rescuer, as for example, in the creation of the world through an accidental "gigantic explosion of matter," or in the origin of life through a chance first "protein life," or in the development of species of living beings through selection, mutation, and so on. In general, chance can be termed the "propitious silent associate" of all great and small "discovery enterprises": it provides, as it were, the signal from an unexplored part of the globe in an as yet undeciphered sign language, and it remains for the creative mind of the discoverer to endow these symbols with meaning and value.

FAVORABLE EXTERNAL CIRCUMSTANCES

Spiritual concentration and conception require solitude, seclusion, and withdrawal from the world in order to increase in strength and fully mature. This belief was widely cultivated in the past by the hermits, the secluded religious orders, the meditators, philosophers, anchorites, recluses, ascetics, prophets or Shamans, all of whom sought a flight into nature and found a spiritual regeneration in "communion with nature." The ancients even located the homes of their gods in the quiet and sublimity of nature, and likewise the shrines, altars, and temples consecrated to divine worship were deliberately placed in such surroundings. In general, from earliest times on, man has tried to escape from the tempo of daily life and the turmoil and noise of the world by taking flight into the blessed stillness of unspoiled nature, so that he might carry out religious rites and listen to his own inner voice.

It was Goethe, who, on his "flight to Italy," and also during his frequent visits to Karlsbad, again and again experienced and emphasized the marked promotion of mental productivity, which he ascribed to the intimate contact with nature in pleasant strolls early in the morning and later in the sunshine, when the senses and the soul invite an appreciation of the restful beauties of nature. In this connection, it is well to note that the great physicist Hermann Helmholtz (1821–94) stated that the genesis of "happy and redeeming ideas" requires that the mind must be thoroughly rested, at an hour of high bodily freshness and physical well-being, say, in the morning shortly after waking from a refreshing sleep, or during a walk through open country such as the easy ascent over wooded heights in sunny weather. Under such circumstances ideas are likely to appear suddenly "as though inspired" and in all clarity. An old German proverb runs: "Morgenstunde hat Gold im Munde." The work-glutton Goethe valued especially the morning hours that were not yet infested with the "trifles of the day."

The counsel of these two intellectual giants can be supplemented by the advice of the eminent physical chemist J. H. van't Hoff (1852–1911). In 1904 he said concerning the origin of his great creation, stereochemistry: "I will give you a recipe for making discoveries. When I, at that time (1874) was going over the Wislicenus paper, I interrupted my study halfway through, to take a walk, and it was under the influence

of the fresh air on this walk that the idea of the asymmetric carbon atom came to me."

The inventors of spectrum analysis, R. W. Bunsen (1811–99) and his friend Gustav Kirchhoff (1824–87) likewise came under this influence of nature. The idea of the joint investigation was born during a walk in the wooded hills around Heidelberg, under the fresh impression of a glorious sunset.

The experience of the Nobel Prize winner, Hans Spemann (1869–1941), is also pertinent. In his autobiography this zoologist writes: "I ought always to be able to work in the open; the thoughts come and take form twice as easily when one has the sky over his head and can look into the distance." He believed that "a fine mental atmosphere is just as necessary for real scientific production as for artistic creation."

The recently published (1949) memoirs of the great organic chemist, Richard Willstätter (1872–1942) contains passages of interest to the present discussion.

> The hour of inactivity was important and fruitful. Productive idleness is a faculty of chosen individuals. One must have the time to wait for "it" to come into our thoughts, and for something to occur to us. The indispensables of living include the unusual, the beautiful, and the friendly-cheerful. . . . After letting it lie and following a long wait—the puzzle solved itself. It solved itself without me, while I was taking my morning bath or knotting my tie. Scientific research is not administrative work. Kekulé believed that the truth came to him in a dream, namely his benzene formula.

Kekulé's dramatic description of his vision or dream picture is justly famous in the history of the evolution of chemical theory. During his stay in London (1853–56) he frequently visited a friend who lived

> . . . at the opposite end of the giant town. We talked of many things, but oftenest of our beloved chemistry. One fine summer evening, I was returning by the last omnibus, "outside" as usual, through the deserted streets of the metropolis, which are at other times so full of life. I fell into a reverie, and lo, the atoms were gambolling before my eyes. Whenever, hitherto, these diminutive beings had appeared to me, they had always been in motion; but up to that time I had never been able to discern the nature of their motion. Now, however, I saw how, frequently, two smaller atoms united to form a pair; how a larger one embraced two smaller ones; how still larger ones kept hold of three or even four of the smaller, whilst the whole kept whirling in a giddy dance. I saw the larger ones formed a chain, dragging the smaller ones after them, but only at the ends of the chain. . . The cry of the conductor: "Clapham Road" [Kekulé's stop] awakened me from my dreaming, but I spent a part of the night in putting on paper at least sketches of these dream forms. This was the origin of the Structure Theory [*i. e.*, the theory of the quadrivalence of carbon and the linking of carbon atoms into chains C_nH_{2n+2}].

This discovery was followed some years later (1865) by another fundamental discovery: the benzene structure. He was then professor at Ghent. One evening, in his home, situated on a narrow quiet side-street, he was working on his "Lehrbuch der Chemie."

> . . . but the work did not progress; my thoughts were elsewhere. I turned my chair to the fire and dozed. Again the atoms were gambolling before my eyes. This time the smaller groups kept modestly in the background. My mental eye, rendered more acute by repeated visions of the kind, could now distinguish larger structures, of manifold conformation: long rows, sometimes more closely fitted together; all twining and twisting in snake-like motion. But look! What was that? One of the snakes had seized hold of its own tail, and the form whirled mockingly before my eyes. As if by a flash of lightning, I awoke; and this time also I spent the rest of the night working out the consequences of the hypothesis.

These visionary and dreamlike musings are typical examples which serve to illustrate the ideational theory of Plato, who asserted: "The kingdom of ideas lies in the dreams and visions of men, in the axioms of the mathematicians and philosophers. . . ."

It should be expressly noted that a mental preparative study and a critical subsequent investigation were required in all of these cases. Another type of intuition and visionary initiation was characterized by Leibnitz: "Nothing occurs to me easily. Yet when someone tells or shows me something, then something better readily comes to my mind." In contrast, Gauss said of his creative activity: "I have my results, but I do not yet know how I arrived at them."

MYSTIC ELEMENTS OF DISCOVERY

Goethe placed the mental creative act or thought in the metaphysical realm, where it was linked with the superterrestrial, the spiritual, the incomprehensible, in general with the unconscious. "All productivity of the highest kind, every significant *aperçu*, every discovery, every great thought, which bears fruit and has consequences, is in no-one's power and is raised above everything terrestrial." In Goethe's opinion, man is merely "a tool of a higher world government, a vessel that has been found worthy of the reception of a divine influence." In the field of artistic creativeness, Brahms believed: "That, which is generally called discovery, *i. e.*, the thought, the idea, is simply a higher inspiration, for which the artist is not responsible, which signifies no merit for him." Likewise, Mahler opined that: "The creation and the origin of a work are mystical from beginning to end, since unconscious to himself, as though by foreign inspiration, one must create something, concerning which he later hardly comprehends how it came about." Nietzsche, the philosopher, characterized the act of inspiration and the launching of the creation in other terms: "Everything occurs involuntarily to the highest degree but as though it occurred in a fury of feeling of being perfectly free, of lack of restraints, of power, of godliness." This complex of unknown and uncontrollable circumstances under which the pioneering scientific or artistic incubation takes place is what we call chance. Goethe said of it: "Foresight sends the chance, man must shape it to purpose." Hence, the mental-spiritual creative act, as a generality, stands in a mystical light and beyond our sensuous experience.

J. R. Mayer (*vide supra*) reported that he got the idea, which led to his discovery (1842), while serving as ship's doctor on a long voyage in the Indian Ocean. While bleeding the sailors, he noted that the venous and arterial bloods were quite similar in color and wondered why. "Several flashes of thought came to me on board ship as we lay off Surabaya. . .where at times

I felt inspired, as it were, in a manner such as I cannot recall ever experiencing before or after." His interpreter, A. Mittasch, commented on this: "In the views and creations of the genius one can actually perceive a motivation and manifestation emanating from the cosmic fields of action, inspiration far transcending the competence and power of the earthly spirit."

Helmholtz likewise speaks—both for science and the arts—of the special importance of "the initial imaginative thought," the "suddenly arising insight" which one cannot call up by methodical reflective meditation; it may be designated as a kind of "divine prompting." We are reminded here of what he once told William Thomson (Lord Kelvin). In discussing his studies on physiological optics, Helmholtz told the astounded English scientist: ". . .since the consequences develop not according to the choice of the author but according to their own law, I often had the impression that what I was putting down was not my own work at all, but I seemed to be recording the work of another." Similarly, it is reported that Mendeleev (1834–1907) envisioned (1869) his spatial arrangement of the chemical elements subconsciously while asleep or dozing. The Nobel prize winner, Carl Bosch (1874–1940), noted his surprise at learning that: "after one has plagued himself months and years with a problem, the mind subconsciously finds the ultimate relationships overnight." The French novelist and essayist André Gide schooled himself to note the thoughts which came to him from the depths of the subconscious in the period of half-sleep just before waking, and then to write them down immediately. He found that the work derived from these contained his clearest and purest ideas and reflections.

Common to all of these statements is the sudden springing into action of "another I," which, as a double superior to the normal "I," seemingly governs the creative functions.

CONCLUDING CONSIDERATIONS

Now as ever, a systematic search, especially along lines previously marked out, remains the most reliable path to new discoveries, but "chance" may also be an additional aid. However, the discovery of the starting point of a new and ramified line of knowledge must be attributed in addition to unusual circumstances and singular chance occurrences. The external conditions discussed previously and the mystic-metaphysical factors can be traced back to three considerations: space, time, and the personality of the discoverer. All the authorities (Goethe, Helmholtz, van't Hoff, Ostwald, Spemann, Willstätter) emphasize the efficacy of the vistas and quiet of natural surroundings, the gently ascending paths through the woods, the sight of the hill tops and coast lines drenched with sunshine. A leisurely stroll or resting at ease can put men into a state of "withdrawal from self and the world," *i. e.*, a feeling of pushing aside the needs and cares of daily life. It is also generally agreed that the most favorable time for the action of these spatial or environmental factors is the early morning, particularly the hours following refreshing sleep, or the peaceful moments at evening and during the night, or in a dream-filled reverie, a half-waking, half-sleeping state, etc.

How does man, the recipient, react to these exogenous influences? It will be necessary, first of all, to construct a picture of their possible essential nature. This involves chance "trace materials"—influxes from the sunny wood, mountain, and sea air, as well as direct cosmic radiations. The result may be a mobilization of certain hormones and activation of the central nervous system. In ordinary language, the creative-clairvoyant state is pictorially characterized as "a streaming into us from outside," *i. e.*, as *in*spiration, *in*fluence, *in*sight, *in*tuition, divination—or because of the sudden independent *in*cidence it is customary to speak of *il*lumination, as, for example, in the case of Kepler, Goethe, Brahms, Mayer, and Helmholtz when they make reference to a "divine direction" or "inspiration from on high."

However, another picture of these mystical-metaphysical changes of state appears possible. What is this thing, this other "I," which suddenly thinks in us, *i. e.*, appears endogenically creative? We are here approaching the realm of the unconscious and subconscious, and no scientific submarine has as yet been able to illuminate the depths of this murky ocean. Wilhelm Ostwald repeatedly describes the "delightful sensation of uniting with nature or of the dissolution in her," or "the remarkable disappearance of the personality," *i. e.*, the conscious sense, when he fled into the stillness of nature. Is this consciously controlled spirit eliminated when we sit dreaming "without thoughts"; does the unconsciously active spirit, with its free mode of thinking, then suddenly appear and arrange the available factual material into new orderly combinations which, as a "flash of thought" suddenly make things clear to us and bring us back to consciousness? The unconscious puts itself into a "complementary relationship" with the conscious.

A practical consequence of these deductions would be to locate scientific research institutes, schools, and to house creative investigators close to open country, where sunshine, quiet, and natural beauty abound. As we have seen, such surroundings are conducive to the release of the individual's mental powers and allow him, as the favored and active member of the creative process, to proceed fully conscious of his responsibility. Such a location would also be a profitable site for the intellectual and material capital of a people.

EXPERIMENTS WITH CYCLOPENTADIENE

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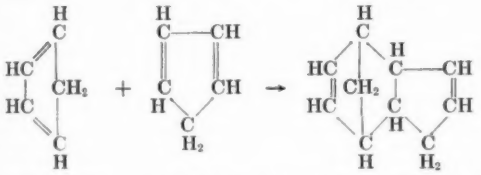
THE experiments outlined below serve to illustrate the processes of polymerization and depolymerization, the Diels-Alder reaction, and the presence of a reactive methylene group in cyclopentadiene.[2] The experiments are simple, requiring no expensive or unusual equipment or chemicals, and the results are striking and convincing demonstrations of the well-defined characteristics of the compounds.

Dicyclopentadiene (dimeric cyclopentadiene) is present in coal tar and is available and inexpensive. At its boiling point (170°) it depolymerizes to cyclopentadiene (b. p. 41°), which is readily obtained by distillation (Experiment 1). Upon storage, cyclopentadiene gradually reverts to dicyclopentadiene by dimerization. The change can be followed by determining the change in specific gravity through a period of some days (sp. gr. of monomer: $0.805^{40°/19°}$; of dimer, $0.976^{35°}$) (Experiment 2). The dimerization is probably a Diels-Alder self-condensation which can be reversed by heat:



Dicyclopentadiene → 4,7-endomethylene-3a,4,7,7a-tetrahydroindene

Both compounds are rapidly and extensively polymerized by concentrated sulfuric acid, with blackening and evolution of heat (Experiment 3). Cyclopentadiene and dicyclopentadiene are used in manufacture of certain commercial resins, in which polymerization is probably linear.[3]

Cyclopentadiene, as a conjugated diene, readily enters into Diels-Alder condensations, of which the spontaneous reaction with maleic anhydride is given below as an illustrative example (Experiment 4). The activity of the methylene hydrogens of cyclopentadiene is illustrated by the formation of diphenylfulvene in Experiment 5.

The chemicals required for these experiments are dicyclopentadiene, benzophenone, maleic anhydride, sodium, and ethanol.

1. Interconversion of Cyclopentadiene and Dicyclopentadiene

Apparatus. For the depolymerization and distillation use a 250-ml. modified Claisen flask.[4] Through the straight main neck introduce a thermometer the bulb of which reaches nearly to the bottom of the flask, where it will be immersed as far as possible in the boiling liquid. Into the side neck, at the head of the Vigreux insert, introduce a second thermometer in position for the distillation. Support the distillation flask on a perforated asbestos board above a burner and connect with the flask a water-cooled condenser. Use as receiver a 50-ml. Erlenmeyer flask, supported on a funnel stand. The receiver need not be weighed.

To follow the repolymerization of cyclopentadiene to dicyclopentadiene there is needed equipment for the determination of specific gravities. A Fisher "Gravitometer" is the most satisfactory apparatus for the purpose, as it requires only small amounts of material and is easy and rapid to use. The Becker No. 110 Chainomatic Specific Gravity Balance, with 2-ml. plummet, is excellent, and by use of a cut-off test tube of minimal bore can be used with about 15 ml. of liquid. The usual Westphal balance, because of the size of the plummet, requires more liquid than will be available in this experiment. The use of a pycnometer is not recommended, owing jointly to its inconvenience, to volatility of the monomer, and to the unpleasant odors of the hydrocarbons. Since high accuracy is not essential (the increase in specific gravity may reach 0.17) a small hydrometer, requiring 10 to 15 ml. of liquid to float, and calibrated for the range 0.8 to 1.0, may be used if other equipment is not at hand.

Procedure. It is advisable to complete the distillation during the early portion of a laboratory period, and to start Experiments 2, 3, 4, and 5 during the same period, so as to use the cyclopentadiene while repolymerization is trivial.

Transfer to the distillation flask about 30 ml. of dicyclopentadiene and introduce several boiling chips. Heat with a small flame, and note that as distillation starts the inside thermometer (bulb in liquid) indicates a temperature of about 170° (the boiling temperature of dicyclopentadiene), but that the second thermometer (bulb in distilling vapor) shows an initial temperature

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[2] The essential chemistry of cyclopentadiene and dicyclopentadiene is given compactly in RICHTER, "The Chemistry of the Carbon Compounds," Nordeman Publishing Co., New York, 1939, Vol. II, pp. 50, 188.

[3] CARMODY, *et al.*, *Ind. Eng. Chem.*, **30**, 245 (1938).

[4] "Organic Syntheses," John Wiley and Sons, New York, 1941, Coll. Vol. I, p. 130, Fig. 9 (*a*).

It is interesting to record that the use of a 3-ball Snyder column led to unsatisfactory results, the prolonged and repeated heatings of condensed liquid about the floating balls leading to partial repolymerization within the column.

of about 41° (the boiling temperature of cyclopentadiene). Adjust the flame so that distillation is steady and at a rate of about 25 drops per minute. At intervals take readings from both thermometers. The inside temperature will rise slowly to perhaps 176°; the temperature of distillation will rise also, but may remain below 50° and should not exceed 65°.[5] Stop the distillation when the liquid in the distillation flask has decreased to about 5 ml. This liquid can be left in the flask as part of the next run by another student. Stopper the receiver tightly and keep the hydrocarbon in a fairly cool place, to minimize loss by volatilization.

2. Spontaneous Repolymerization of Cyclopentadiene

Determine the specific gravity of the freshly distilled cyclopentadiene and that of the original dicyclopentadiene and record the values and the temperatures. Thereafter determine and record the specific gravity of the distillate at intervals of one or two days, until the value approaches or equals the specific gravity of the dimer (0.976 at 35°). Plot the results: specific gravity versus time. The rate of dimerization is of course affected by temperature, but if no large fluctuation in temperature occurs a smooth curve should be obtained.

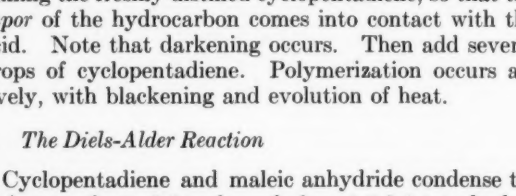
3. Extensive Polymerization of Cyclopentadiene and of Dicyclopentadiene by Acid

(*a*) *Dicyclopentadiene.* To one drop of concentrated sulfuric acid on a small watch glass add one drop of dicyclopentadiene, and stir with a short glass rod. Note the darkening and resinification as the hydrocarbon polymerizes.

(*b*) *Cyclopentadiene.* Spread a drop of concentrated sulfuric acid on a small watch glass, and bring over it and close to it the mouth of the (inclined) flask containing the freshly distilled cyclopentadiene, so that the *vapor* of the hydrocarbon comes into contact with the acid. Note that darkening occurs. Then add several drops of cyclopentadiene. Polymerization occurs actively, with blackening and evolution of heat.

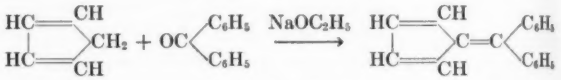
4. The Diels-Alder Reaction

Cyclopentadiene and maleic anhydride condense together to form 3,6-endomethylene-1,2,3,6-tetrahydrophthalic anhydride.

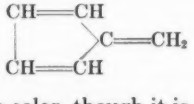


Procedure.[6] Transfer 0.5 g. of maleic anhydride (0.005 mol; m. p. 57–60°) to a dry 50-ml. Erlenmeyer flask and chill in ice. While chilling and shaking add in small portions 1 ml. of freshly distilled cyclopentadiene. Reaction is immediate and evolves heat, which may cause some of the hydrocarbon to boil off.[7] The entire mixture solidifies on cooling. To it add 4 ml. of 95 per cent ethanol, effect solution by brief warming on a water bath (the solution will probably be turbid), and filter through a small fluted paper into a second 50-ml. Erlenmeyer flask. Rinse the first flask with 0.5 ml. of hot ethanol and use this also to wash the filter. Chill the solution in ice and collect the crystals in a Hirsch funnel or similar device, using the filtrate to transfer remaining crystals to the filter. Wash the product with 0.5–1 ml. of chilled ethanol. Dry the crystals in air or in a desiccator and determine the melting point. The yield is about 0.4 g. The pure product melts at 164–165°; as obtained here it may melt several degrees lower.

5. Preparation of Diphenylfulvene



This condensation illustrates the activation of the methylene hydrogens of cyclopentadiene. Diphenylfulvene, a stable derivative of the hypothetical fulvene



has a deep orange color, though it is a hydrocarbon and is derived from two colorless compounds. The reason for this strong color becomes clear when there is considered the high degree to which the unsaturation of the molecule is involved in extended conjugation.

Procedure.[8] Dissolve 0.5 g. (0.02 mol) of freshly cut sodium in 15 ml. of 95 per cent or absolute ethanol in a 50-ml. Erlenmeyer flask, while cooling under the tap. To this liquid add 3.6 g. (0.02 mol) of benzophenone, most of which dissolves. Now introduce 1.6 ml. (1.3 g.; 0.02 mol) of freshly distilled cyclopentadiene, while swirling the mixture, and after several minutes warm it gently. The mixture develops a deep red color. Chill in an ice bath; if this fails to cause separation of solid material evaporate some of the alcohol by gentle warming and again chill. To assure separation of the product keep the mixture in an ice bath or refrigerator for some hours or overnight. Collect the crude product in a Büchner funnel, pressing well and drawing the mother liquor through as completely as possible. Wash the solid with 2 to 3 ml. of chilled alcohol, and dry in the air or in a desiccator. The crude diphenylfulvene weighs about 3 g. and should melt at about 81° to 82°.

The appearance of the product is much improved by recrystallization from alcohol. For this purpose dissolve it in 20 ml. of hot 95 per cent ethanol, filter hot

[5] When a 3-ball Snyder column was used, the temperature of distillation rose quickly to 115°.

[6] DIELS AND ALDER, *Ann.*, **460**, 98 (1928).

[7] This procedure is not a good one for preparative purposes, since a large excess of cyclopentadiene is specified to compensate for the loss by volatilization during the exothermic reaction.

[8] THIELE, *Ber.*, **33**, 672 (1900).

through a fluted paper (some black tarry material is thus removed), and use about 5 ml. more of hot ethanol to wash flask and filter paper. Chill the filtered solution in ice, collect the crystals in a Büchner funnel, and wash with 5 ml. of chilled ethanol. The product is thus obtained as deep orange leaflets; recovery is about 80 per cent. The melting point is 81° to 82°; the m. p. of pure diphenylfulvene is 82°.

A SLIDE RULE FOR AVERAGING GRADES OR EXPERIMENTAL DATA

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In order to save time and increase accuracy in averaging student grades, a circular slide rule of special design was found to be very satisfactory. The rule consists of two concentric movable discs and a hairline marker of transparent plastic. The larger of the discs carries a perfectly regular scale completely around it, numbered from 0 to 100. The smaller disc, which can be rotated upon the larger, carries a series of scales of angular lengths, $1/2$, $1/3$, $1/4$, etc., down to $1/20$ of the length of the fixed scale. These scales are marked 2, 3, 4, etc., up to 20, and are used for averaging 2, 3, 4, etc., up to 20 two-digit grades or instrument readings. For example, if 35, 60, and 72 are to be averaged, the hairline is set simultaneously at the 100 mark on the outside disc and the zero point of the scale marked 3 (since three figures are to be averaged). Then the hairline is moved to 35 on the No. 3 scale and held in position by pinching the end of the marker and the edge of the large disc. The smaller disc is then rotated until the zero point of the No. 3 scale is again under the hairline and the marker moved to 60 on this scale. The end of the marker and edge of the large disc are again pinched and the inside disc rotated to that the zero point of the No. 3 scale is again under the hairline and the hairline moved to 72 on this same scale. The average of the three numbers can now readily be determined on the outside scale as 55.6. It will be seen that actually one is merely stepping off and thereby adding on the large outside scale, a third of 35, a third of 60, and a third of 72, and the sum is the average of the three. The division by three is brought about automatically, since the angular length of the No. 3 scale is exactly one-third of the length of the large outside scale. If four numbers are to be averaged, the No. 4 scale is used, and up to twenty figures can be averaged by choice of the appropriate scale. In averaging large numbers of figures, the slight errors unavoidable in each individual setting tend to cancel out so that the final average is not greatly in error. In most cases the average calculated by the rule is within 0.2 of a unit of the true average.

If more than twenty figures are to be averaged, as for example, in determining a class average, the total number of figures can be divided into halves, thirds, or some other fraction and the average of each fraction determined, and then these figures averaged. It is obvious that if thirty-seven grades are to be averaged, two groups, one containing 18, and the other 19, could be averaged separately, and then these two figures averaged equally on the No. 2 scale, without introducing an appreciable error. For weighted averages, for example, of three figures, one weighted 3, the second 2, and the third 1, the No. 6 scale is selected and the first figure is stepped off three times, the second, twice, and the third, once. The rule can be used to average experimental data or instrument readings or any other figures which differ only in the last two digits.

Average Calculator

This slide rule has been used by the author for the past year for averaging student grades, and has been estimated to reduce the time involved to less than one-half, while decreasing considerably the chance of making serious and embarrassing mistakes. It makes unnecessary the copying of grades from grade books for addition or division, the only figure which need be written down being the final average.

THE LANTHANIDE CONTRACTION AS A TEACHING AID[1]

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AT BEST only a minute fraction of the enormous bulk of recorded chemical facts can be grasped and retained by any individual. Perhaps because of this limitation, a natural tendency among chemists has been to search for means of organizing and classifying these facts. One of the most popular devices for this purpose is the periodic table. The remarkable success of this table stems from the fact that it emphasizes the interplay of two fundamental properties of the atoms—size and electronic structure. The qualitative *similarities* of the elements in the familiar "families" or groups of the periodic table result predominantly from similarities in the outermost electronic structures of their atoms, while the *variations* within a family arise mainly from differences in the sizes of the atoms. In comparing properties of ions, an additional important factor—the charge—must be considered. Qualitative similarities in chemical properties may be anticipated, then, among *atoms* when their sizes and outermost electronic structures are similar, and among *ions* when their sizes, outermost electronic structures, and charges are similar. We shall examine in some detail the variations in properties accompanying variations in atomic and ionic sizes, particularly in that portion of the periodic table in which the lanthanide rare earths occur.

[1] Presented in part before the Division of Chemical Education at the 118th Meeting of the American Chemical Society in Chicago, Illinois, September 4, 1950.

ATOMIC VOLUMES

A favorite method for graphically depicting the variations in size of the atoms of the elements involves plotting atomic volume as a function of atomic number. In this way the familiar atomic volume curve (Figure 1). is obtained. The term "atomic volume" is ordinarily understood to mean the volume in cubic centimeters occupied by one gram atomic weight of the element in the solid state. It is calculated from the formula,

$$\text{Atomic volume} = \frac{\text{atomic weight}}{\text{density}}$$

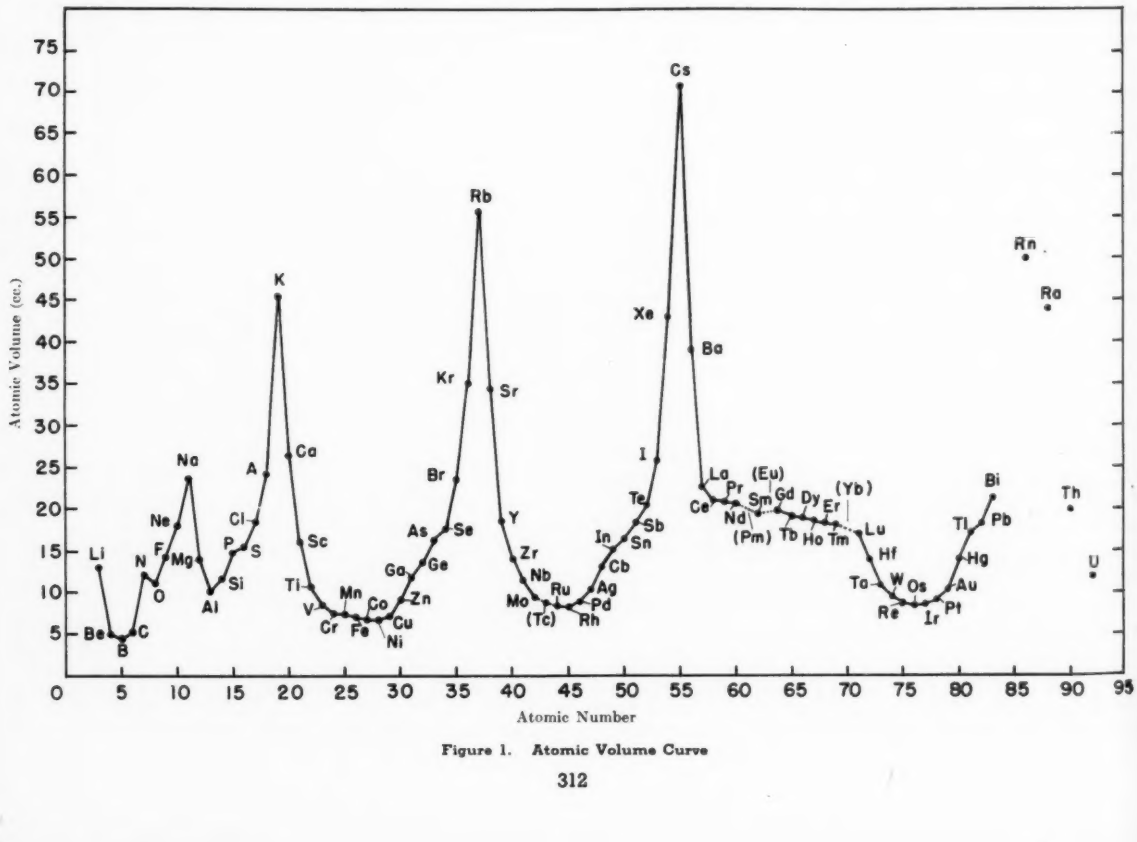

Figure 1. Atomic Volume Curve

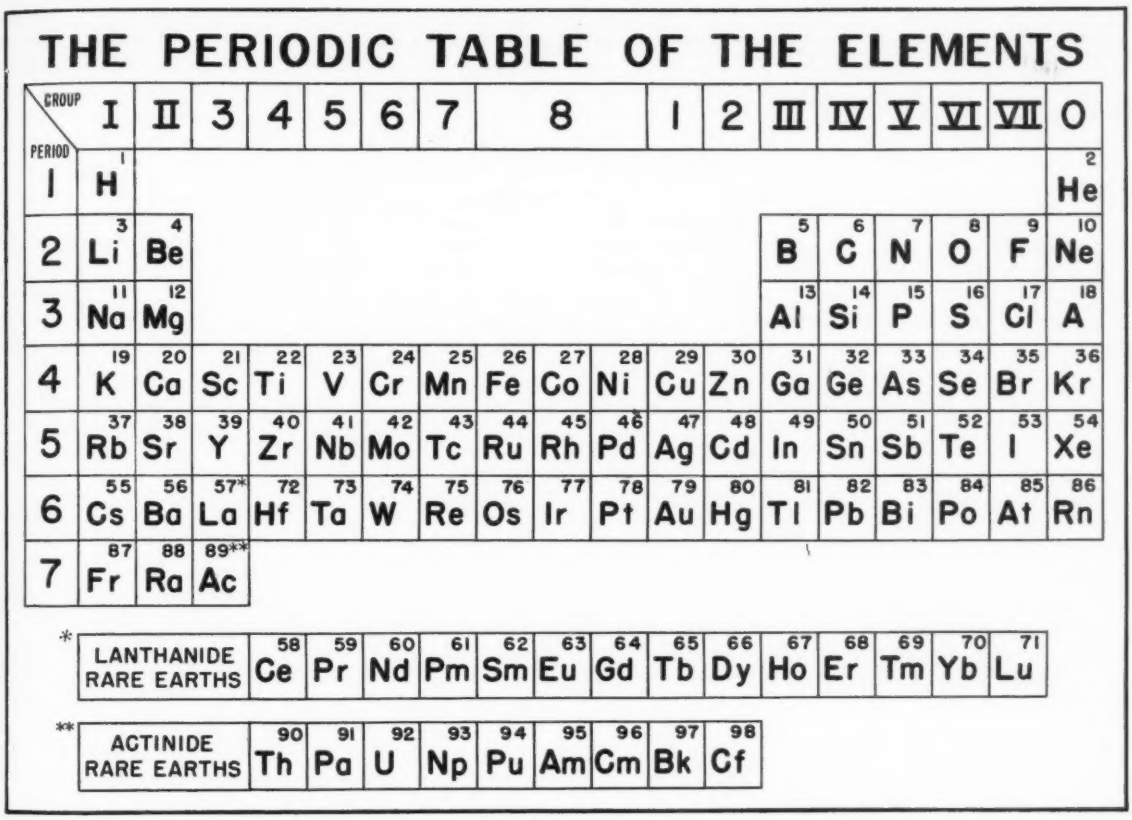
THE PERIODIC TABLE OF THE ELEMENTS
GROUP I II 3 4 5 6 7 8 I 2 III IV V VI VII 0
PERIOD
1 1 H 2 He
2 3 Li 4 Be 5 B 6 C 7 N 8 O 9 F 10 Ne
3 11 Na 12 Mg 13 Al 14 Si 15 P 16 S 17 Cl 18 A
4 19 K 20 Ca 21 Sc 22 Ti 23 V 24 Cr 25 Mn 26 Fe 27 Co 28 Ni 29 Cu 30 Zn 31 Ga 32 Ge 33 As 34 Se 35 Br 36 Kr
5 37 Rb 38 Sr 39 Y 40 Zr 41 Nb 42 Mo 43 Tc 44 Ru 45 Rh 46 Pd 47 Ag 48 Cd 49 In 50 Sn 51 Sb 52 Te 53 I 54 Xe
6 55 Cs 56 Ba 57* La 72 Hf 73 Ta 74 W 75 Re 76 Os 77 Ir 78 Pt 79 Au 80 Hg 81 Tl 82 Pb 83 Bi 84 Po 85 At 86 Rn
7 87 Fr 88 Ra 89** Ac
* LANTHANIDE RARE EARTHS 58 Ce 59 Pr 60 Nd 61 Pm 62 Sm 63 Eu 64 Gd 65 Tb 66 Dy 67 Ho 68 Er 69 Tm 70 Yb 71 Lu
** ACTINIDE RARE EARTHS 90 Th 91 Pa 92 U 93 Np 94 Pu 95 Am 96 Cm 97 Bk 98 Cf

Figure 2

Inasmuch as all gram atomic weights contain the same number of atoms, atomic volumes can be used as qualitative guides to the relative volumes of the individual atoms. An atomic volume curve is at best, however, only an approximation (*1*). In calculating atomic volumes no allowances are ordinarily made for differences in crystal structures of the solids, variations of the atomic volumes with temperature, differences in atomic aggregation of the elements in the solid state, etc.[2]

Notwithstanding the above inherent deficiencies, the atomic volume curve bears a number of interesting features (*2*), some of which are cited below.

(1) The periodic relationship between atomic volume and atomic number is strikingly shown.

(2) The alkali metals, with extraordinarily large volumes, occupy the maximum points of the curves while elements near the middle of both the short and long periods of the ordinary periodic table (Figure 2) have relatively small volumes and occupy the troughs of the U-shaped curves.

(3) The gaseous, volatile, or easily fusible elements lie at the peaks or on the rising portions of the U-shaped curves, whereas the nonvolatile or difficultly fusible elements lie either in the troughs or on the descending portions of the curves.

(4) In atomic volume, as in most other properties, there appears to be less variation from element to element among the transition metals (Sc to Cu, Y to Ag, and La, Hf to Au) than there is between elements outside these groups.

(5) The addition of one *s* electron on top of an inert gas structure results in a marked increase in volume (alkali metals).

(6) The addition of a second *s* electron, however, results in a marked decrease in volume (alkaline earth metals).

(7) The filling of a *p* subshell in the long periods results in a steady increase in atomic volume (*cf.* Cu to Kr,

[2] Data for the curve in Figure 1 were obtained from the literature or calculated from the best available values for densities. Dotted lines are used where no values are available as at Tc and Pm. No values for hydrogen and helium are plotted. Calculations of atomic volumes for the rare earths from densities and atomic weights give abnormally large values for Eu and Yb. Since there are no corresponding irregularities in ionic radii at these points for the tripositive ions of the rare earths, there is some question as to whether the atomic volumes for Eu and Yb are meaningful as guides to relative atomic sizes. These values may be merely reflecting the fact that Eu and Yb crystallize in the cubic system as distinct from all the other rare earth metals which crystallize in the hexagonal system (*3*). Because of this uncertainty and in order not to detract from the more important over-all trend within the family, the values for Eu and Yb are omitted from the curve.

Ag to Xe, and Au to Rn). Except for a slight irregularity in the first period, the same general tendency appears in both short periods.

(8) Filling a *d* subshell (transition elements) results in general in a decrease in volume until the subshell is filled or almost filled.

(9) Filling an *f* subshell (rare earths) likewise results in a decrease in atomic volume.

The above facts and trends are significant in interpreting, correlating, and predicting properties of the elements. Unfortunately, it is not easy to transfer the information contained in the curve as drawn in Figure 1 to a family or group basis. To be sure, elements of a given family occupy approximately corresponding positions on the curves and a decided trend can be readily followed. For example, it is quite apparent from Figure 1 that the atomic volumes or sizes of the atoms of the alkali family increase from lithium to cesium. However, it is much less obvious as to what has happened in the case of vanadium, niobium, and tantalum.

In Figure 3 the atomic volumes for the three long periods are plotted in such a manner that the familiar families or groups of the periodic table are preserved, with one obvious difference—that most of them are inverted. The individual values for the rare earth elements are omitted but the range in atomic volumes covered by the entire family is indicated between lanthanum and hafnium. It is clear, when the data are plotted in this fashion, that the decrease in atomic volume of the rare earths results in the elements of the third long period being practically superimposed upon those of the second, starting with the elements zirconium and hafnium and continuing as far as silver and gold. The diminution in volume which begins with lanthanum and continues through the rare earths has become known as the "lanthanide contraction" (*2*, *7*, *8*, *9*). This contraction appears to be related to the fact that the successive electrons which are being added from cerium to lutetium are not added to a new external shell, well shielded from the nucleus, but to an inner shell which previously had been only partially filled. Thus, with an ever-increasing charge on the nucleus from 58 to 71 but with no compensating increase in the distance from the nucleus of the entering electrons, the whole electronic system shrinks.[3] This same phenomenon is evidently occurring also in the building up of the transition elements (see Figures 1 and 3).

The dotted line in Figure 3 represents a hypothetical atomic volume curve for the elements of the third long period on the assumption that no rare earths intervene beween lanthanum and hafnium and the general shape of the curve approximates that of the other long periods. If this were the actual situation, a more or less uniform variation in properties should be expected between any two successive members of a given family. However, as a result of the lanthanide contraction it will not be surprising to find irregularities or actual reversals of trends within a post-rare-earth family between the elements of the second and third long periods. Tables 1, 2, 3, and 4 give the trends for several properties of blocks of elements, some of which precede and some of which follow the rare earths in the periodic table.

[3] An analogous effect has been reported recently (*10*) in the actinide series of rare earths from Ac (atomic number 89) to Am (atomic number 95).

TRENDS IN PROPERTIES

In Table 1 a section of the long form of the periodic Table (Figure 2) is reproduced with the values for the atomic volumes of the elements indicated. Between lanthanum and hafnium, of course, the fourteen rare earth elements are omitted. As already indicated graphically in Figure 3, the atomic volumes of the elements in the first two columns of Table 1 increase going downward. This trend is interrupted in the next column at zirconium and hafnium, whose atomic volumes are practically identical within experimental error, and may be actually reversed at niobium and tantalum. At any rate, it is clear that the atomic volumes of niobium and tantalum and of molybdenum and wolfram are quite similar.

TABLE 1
Atomic Volumes (cc. per gram atom)

Ca	Sc	Ti	V	Cr
26.4	16	10.6	8.55	7.5
Sr	Y	Zr	Nb	Mo
34.4	18.5	14	11	9.4
Ba	La	Hf	Ta	W
39	22.6	~14	10.9	9.5

Table 2 includes the same group of elements as in Table 1 and lists the values for their respective densities (*11*, *13*). The most striking feature of this table is the extraordinarily large values for hafnium, tantalum, and wolfram—that is, for those elements following the rare earths. This is to be expected, of course, in view of the close similarity in atomic volumes of these elements and those directly above them. From the formula for atomic volume it follows that if two elements have similar values for their atomic volumes the one with the greater atomic weight must also have the greater density. The difference in atomic weights between zirconium and hafnium, for instance, is approximately 87 yet they have almost identical atomic volumes.

TABLE 2
Densities (g. per cc.)

Ca	Sc	Ti	V	Cr
1.5	2.8	4.5	6	6.9
Sr	Y	Zr	Nb	Mo
2.5	4.8	6.5	8.4	10.2
Ba	La	Hf	Ta	W
3.5	6.1	12.8	16.6	19.3

In Table 3 approximate values are given for the apparent ionic radii (*12*, *14*, *15*, *16*) of the ions of these same elements for the highest charge characteristic of their respective groups. Again, the effect of the lan-

thanide contraction on the trends in ionic sizes is obvious.

Selected families of elements, some preceding and some following the rare earths, are listed in Table 4 along with the values for their first ionization potentials (*17*). The table reveals that the maximum value for this property is reached with the first member of the families preceding the rare earths whereas for families not too far removed from the rare earths the exact reverse appears to be the case.

TABLE 3
Ionic Radii (Angstrom units)

Ca^{+2}	Sc^{+3}	Ti^{+4}	V^{+5}	Cr^{+6}
1.0	0.8	0.65	0.6	0.5
Sr^{+2}	Y^{+3}	Zr^{+4}	Nb^{+5}	Mo^{+6}
1.1	1.0	0.8	0.7	0.62
Ba^{+2}	La^{+3}	Hf^{+4}	Ta^{+5}	W^{+6}
1.3	1.2	(0.8)	0.72	0.65

CHEMICAL CONSEQUENCES

A number of the outstanding chemical consequences of the lanthanide contraction can now be summarized.

Nonuniform and Reversed Trends in Post-Rare-Earth Families. In an examination of the properties of the elements in the preceding tables, it is not surprising that decided differences appear between the elements on either side of the rare earths. Dropping out 14 elements between lanthanum and hafnium can hardly pass unnoticed. What is somewhat surprising, is the specific nature of these differences. It would not seem at all unreasonable to postulate, for example, that as the result of this omission the atomic volume of hafnium should be larger than that of lanthanum and much larger than that of zirconium. That this is not the case has already been pointed out in connection with Table 1.

In the event of either a "lanthanide contraction" or a "lanthanide expansion," the trends in properties of

TABLE 4
First Ionization Potentials (electron volts)

K	Ca	Sc	Cr	Fe	Ni	Cu	Zn	Ga	Ge	As
4.32	6.09	6.7	6.74	7.83	7.61	7.68	9.36	5.97	8.09	10.5
Rb	Sr	Y	Mo	Ru	Pd	Ag	Cd	In	Sn	Sb
4.16	5.67	6.5	7.2	(7.7)	8.3	7.54	8.96	5.76	7.30	8.35
Cs	Ba	La	W	Os	Pt	Au	Hg	Tl	Pb	Bi
3.87	5.19	5.59	8.1	8.7	8.88	9.19	10.38	6.07	7.38	7.25

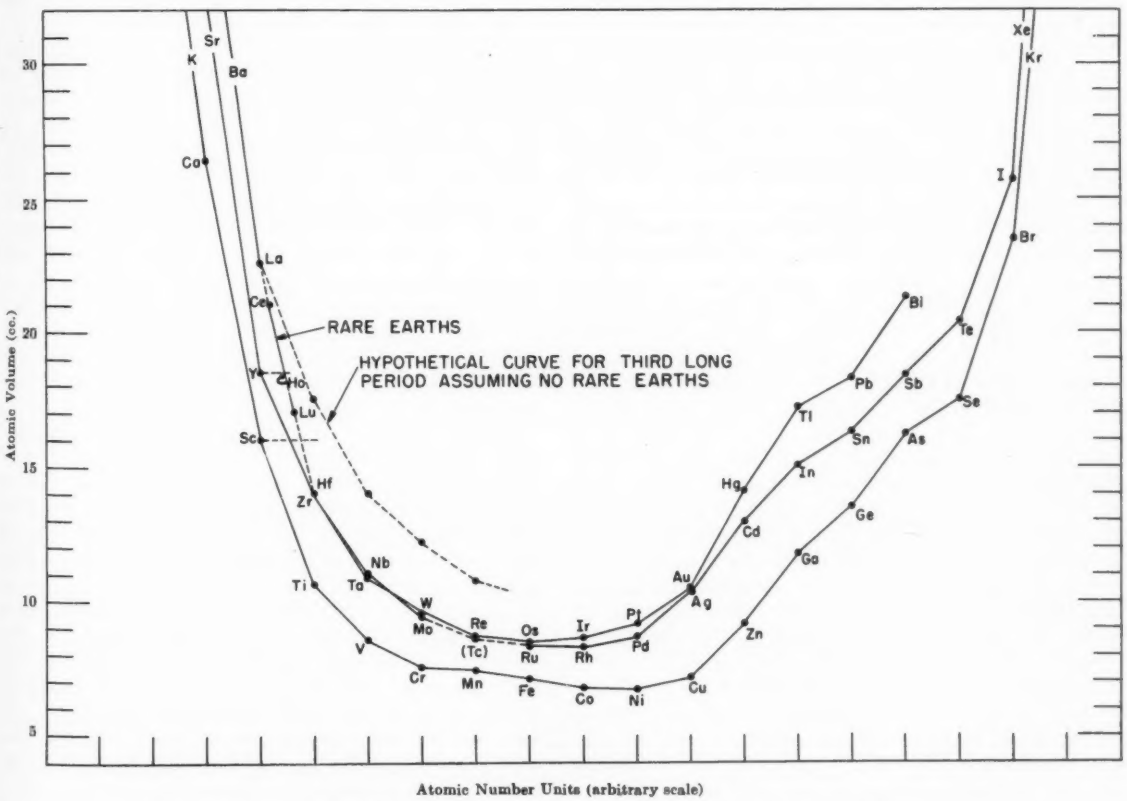

Figure 3. Atomic Volume Curves Showing Group Relationships among the Long Period Elements

families containing an element following the rare earths are likely to be markedly different from the trends for those families all members of which precede the rare earths. This is clearly indicated for the atomic volumes in Table 1, densities of the solid elements in Table 2, and ionic radii of similarly charged ions in Table 3.

Ionization potentials are related to the tightness with which outermost electrons are held by atoms and are therefore important chemically. The first ionization potential refers to the energy necessary to remove the most loosely bound electron from the gaseous atom. There is, of course, no chemical equivalent of this reaction but nonetheless the energy involved is significant in interpreting properties of atoms. For the families preceding the rare earths the usual trend is decreasing ionization potential with increasing atomic number (Table 4). This is one of the factors which, for example, is responsible for the increase in chemical activity and basicity (*4*, *18*) of these elements going downward in the families. Unfortunately, reliable values for ionization potentials are not available for all the elements of families following the rare earths. From the data of Table 4, less well-defined trends seem the rule among these elements, yet at the same time unexpectedly large values are uniformly indicated for those elements in the third long period which follow the rare earths. Indeed, these values exceed even those for the first members of the respective families. This is one of the reasons, for example, why gold is the most noble of the copper group elements instead of the most active. The enhanced values for the ionization potentials for the elements of the third long period may be qualitatively associated with the fact that the atomic sizes of the corresponding elements in the second and third long periods are approximately the same (Figure 3) whereas the nuclear charges of the latter are very much greater (Figure 2). This effect seems to be clearly marked as far removed from the rare earths as the gallium-indium-thallium family of elements. Lead, in the next family, has a value greater than tin but less than germanium, the first member of the family. In the arsenic-antimony-bismuth family, the "normal" trend returns.

Decreasing Basicity of the Rare Earths with Increasing Atomic Number. The usual trend among atoms which are electronically similar is an increase in basicity (*4*, *18*) with an increase in atomic number. For example, cesium is more basic than lithium and iodine is more basic than fluorine. This trend results because with increasing atomic number there is normally an increase in atomic or ionic size. However, in the rare earth series this trend is completely reversed, lanthanum being the most basic instead of the least as might be supposed. In fact, $La(OH)_3$ appears to be one of the strongest hydroxides of any trivalent metal. Due to the regular decrease in ionic size from La^{+3} ($\sim$1.2 Å.) to Lu^{+3} ($\sim$1.0 Å.), an increase in atomic number among these elements is accompanied by a uniform decrease in basicity (*5*). The slight difference in basicity between successive rare earth elements is the basis for a number of procedures for separating them (*5*, *20*).

Chemical Resemblance of Hafnium to Zirconium. It is a remarkable fact that zirconium and hafnium, differing in atomic weight by 87 units, are so alike chemically that their separation has taxed the ingenuity of analytical chemists for years (*22*). This unexpected likeness becomes understandable when the role of the lanthanide contraction is considered (*23*). Chemical reactions of atoms and ions depend to only a slight degree on their masses but to a high degree on their electronic make-up and charge. Zirconium and hafnium, which are in the same group in the periodic table, have similar external electronic configurations and, due to the lanthanide contraction, their atoms and tetrapositive ions are almost identical in size. Thus, the conditions which favor similarity have been conferred accidentally upon these two elements to a degree not found between any other pair in one family but in different periods of the periodic table.

Similarities between Other Pairs of Elements. Pronounced similarities between the corresponding elements of the second and third long periods of the periodic table are in no wise limited to zirconium and hafnium. The effect of the lanthanide contraction is projected well beyond these elements, so much so in fact that it is common practice among textbook writers and teachers to consider niobium and tantalum in Group V and molybdenum and wolfram in Group VI as "natural" pairs. Presumably the same relationship should exist between technetium and rhenium.

The striking resemblances of ruthenium to osmium, rhodium to iridium, and palladium to platinum are undoubtedly associated with this same phenomenon. The horizontal or series relationships in the transition elements appear to reach their culmination in the triads of Group VIII. As a result of the combined effect of the similarities in a horizontal direction among the Group VIII elements and the similarities in a perpendicular direction arising as a result of the lanthanide contraction, these six so-called platinum metals are usually treated as one group of closely related elements. The similarity of iron, cobalt, and nickel to the corresponding elements in the second long period is distinctly less than that between the latter elements and their analogues in the third long period.

While silver and gold resemble one another more than either resembles copper, in general the effect of the lanthanide contraction on the properties of the elements beyond the transition elements is less tangible. There is some evidence, however, that this phenomenon may be exerting a subtle influence on the properties of elements as far removed as francium (*24*).

Rare-Earthlike Properties of Scandium and Yttrium. Scandium and yttrium are not, in the strict sense, rare earths yet these elements occur in a number of rare earth minerals and both, notably yttrium, go along with the rare earths in many analytical procedures. In fact, one of the common groups into which the rare earths are frequently divided for convenience is known as the yttrium-group (*6*). An insight into this apparent anomaly can be obtained by reference to Figure 3.

The diminution in atomic volume of the rare earths with increasing atomic number is such that the atomic volume of yttrium is reached near holmium, as indicated by the dotted line drawn through the value for yttrium. However, the smaller volume of scandium is not quite attained even by the heaviest rare earth. The combination of effects among these elements results in the following interesting order of *decreasing* ionic size for the tri-positive ions and *decreasing* basicity for the group (*19, 25*): La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Y, Ho, Er, Tm, Yb, Lu, Sc. In view of this it is perhaps less surprising to find yttrium concentrating with holmium, and scandium concentrating with the heaviest rare earths during many fractionation procedures involving these elements (*21*). This latter fact is difficult to explain on any other basis inasmuch as scandium, the lightest of the Group III transition elements, resembles not the rare earths nearest to it in atomic weight but rather those whose atomic weights are most remote.

CONCLUSION

The chemical implications of the decreasing atomic volume and decreasing ionic size which occur in the lanthanide series of rare earth elements have been adequately discussed in original journal articles but the potentialities of this phenomenon as a teaching device appear to have been largely overlooked by most textbook writers and teachers. Presented in this paper is a modified form of the atomic volume curve which illustrates graphically the effect of the so-called lanthanide contraction. Also a number of the chemical consequences of this effect are discussed. The author believes that many of the seeming anomalies of the periodic table become explicable when considered in the light of the factors which contribute to similarities or dissimilarities in chemical properties among the elements.

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JAMES FLACK NORRIS AWARD

The first James Flack Norris Award of $1000 for distinguished service in the teaching of chemistry and the first such award ever given was presented to George Shannon Forbes. The award and a scroll were given to Dr. Forbes on May 10, in ceremonies and a dinner at the Harvard Club, Boston, attended by leading educators and industrialists, and 500 members of the Northeastern Section of the American Chemical Society.

Dr. Forbes received the Norris Award in recognition of his 44 years of outstanding teaching of chemistry at Bryn Mawr College, Harvard University, Radcliffe College, and Northeastern University. "His lectures," the citation says, "are presented with meticulous care and punctuated with an ingenious wit which endeared him to thousands of undergraduates. His sympathetic patience, insistence on quality and many-sided friendliness to his graduate students has inspired them to do their finest work. At a peak of accomplishment where many might slacken their efforts, he continued to teach with an enthusiasm, energy, and integrity which are an example to his professional colleagues."

CHEMISTRY AS A LIBERAL ART[1]

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THESE are the days of the great default in liberal education. It is significant that the chemists are setting aside a period at their professional meeting for the discussion of liberal education. It means that the neighbors have been called in to consult on an illness at the very center of our culture. The victim of the illness welcomes the consultation; he has had need of it for a long time. Other professional societies have also been called in because their help is also needed, but the chemists are particularly welcome. If chemists can find a way to make their basic contribution to liberal teaching, the other neighbors can hope to be effective also. Chemistry for half a century has been the worst problem in the liberal curriculum. It may not be irrelevant to note that this is the period between the presidencies of Charles Eliot and James Conant at Harvard. Both men, each in his own way, have helped to formulate the problem and to offer solutions. Both men, if they were here, would be first to admit that the problem is unsolved.

But before I enter into these difficulties, I want to propose an explanation of the default in liberal education. The default itself consists in uncertainty and disagreement concerning the aims of liberal teaching. Before the days of Charles Eliot it was commonly and simply understood that liberal education, education of the free man, was essential as the basic training for the professions, theology, law, and medicine, for those whose careers would be devoted to the public interest. Such persons were the leaders in the life of the community, and they were therefore a small minority of the population. Eliot was concerned that the education of this vital minority should not be restricted to the rote learning of Greek, Latin, and mathematics to which the traditional teaching of the liberal arts had been reduced. He was aware that the modern community depended, not only for its higher professional functions but also for its basic survival, on the new learning to which the liberal arts had led, the natural sciences including chemistry. He did not undertake to formulate a new encyclopedia of instruction for the small republic of learning of that time, but rather he established a free market in ideas and courses, in which the new sciences would have equal opportunity and would be equally available to students, a fair field and no academic favors. For two generations we have been living academically under the elective system. To put it mildly, the invisible hand that is supposed to guide free markets has not proved wholly providential.

President Conant has come heir at Harvard to the free academic market. One of the consequences of it, which President Eliot could not have foreseen, is that the common learning once needed only for the professional leaders of the community, is now needed under modern industrial conditions by a wider and wider majority. In fact it is needed desperately by the common man who in a democratic society has to make the common decisions of the community. As Epictetus, the philosophical slave, said centuries ago: "Man has said that only free men shall be educated, but God has decreed that only educated men shall be free." A free industrial society is now saying that the liberal arts are for everybody, not merely as a privilege or duty, but as a social necessity. This is the way the Committee of President Conant's faculty have seen the problem. Their report on "general education in a free society" offered a *modus vivendi* rather than a solution to the problem. Incidentally the weakest part of the report dealt with the natural sciences, and Mr. Conant himself had to take off his administrative coat and participate in the explorative teaching that the report recommended.

One trouble with this report was that it did not penetrate to the principle and nerve of liberal teaching. The principle of liberal teaching must be intellectual, and its aim must be the awakening of intellectual curiosity in the student and the establishment of those intellectual habits by which a student becomes his own teacher for the rest of his life. The intellectual process must become self-perpetuating; the insights induced in the classroom and laboratory must be such that they will generate other insights. This means that subject matters must be sorted and selected to provide the kind of basic understandings that crucial experiments contribute to science. Since this criterion probably demands more understanding than the academic community has of its present subject matters, our basic trouble is a very dangerous one, an intellectual chaos.

The difficulties that liberal arts colleges have with chemistry, chemists, and departments of chemistry are manifold. Many of them are superficial, but nonetheless chronic and frustrating. One set of them seems to be managerial: the laboratory equipment dictates a dangerous bulge in the budget, running expenses reflect the high cost of research added to the cost of teaching, salaries for good personnel have to compete with an industrial scale; the high rate of consumption of time in laboratory periods dislocates the schedules of both teachers and students, and quarrels about such matters irritate and discourage the instructors enough to damage their morale and the standards of their teaching; members of the faculty come to meetings of the cur-

[1] Presented at the 118th Meeting of the American Chemical Society, Chicago, September, 1950.

riculum committee full of righteous indignation and the will to veto. A second kind of difficulty is still superficial, but it comes nearer to the central trouble. Students who show the first signs of liberal artistry, that is, have caught the habits of intellectual curiosity but have few of the skills which support them, react with angry frustration to their first contacts with chemistry. This is partly due to the low morale that the elective system generates, and the resulting demand that instruction shall always be interesting; partly due to the fact that many chemists have little experience or sympathy with the all pervasive questions with which liberal teaching is concerned; and partly due to the opaque formulary content of chemistry which delivers its significance only to those who have the operational habits of the professional practitioner. A theoretical question asked by an explorative student or an inquisitive colleague is commonly responded to with self-defensive anger on the part of the chemist; such questions seem to call in doubt the competence and integrity of a whole profession. I know persons who more or less deliberately and regularly indulge in the academic sport of baiting the chemist, and, as a dean, I found it my duty to discipline students who imitated their elders in this game. The game gets rough when it is played by mathematicians and physicists who view the chemist's answers as stolen property.

The humanists, who have lost considerable intellectual integrity since the renaissance, but who still see themselves as the guardians of the surviving fragments of the liberal arts, view the open market that President Eliot invited them to enter as a trap set by a chemist. The professor of chemistry looks to them like a field agent of the industrial corporation, scouting in the academic market for human material to exploit. His demands for prerequisites and majors seem to have all the force and threat of the industrial world back of them, and the graduate school of chemistry is a special device for distorting and monopolizing the liberal college whose defenses have been brushed aside in the elective system. The humanist's resentment is particularly acute when he hears students who have many interests told that they must choose between the humanities and chemistry on pain of losing their professional careers.

Familiar with all these painful and puzzling symptoms of civil war throughout my academic life, wrestling with their administrative consequences, and exploring the causes of them in my more speculative moments, I welcomed a definitive explanation of them by a medical friend some years ago. He had decided, he said, that chemistry is a system of cookery; it borrows its intelligibility from other sciences, and it has no intellectual or theoretical base of its own. It is an operational sophistry, inventing and using formulas that it does not even pretend to understand. These are harsh words, but as a hypothesis they threw a good deal of light on my own speculations. The acceptance of formulas, spun out of the periodic table, as the subject matter of chemistry had always reminded me of the rules, paradigms, conjugations, and declensions of the classical grammarian and his bad temper in enforcing rote memory as a pedagogical discipline. The simile of cookbook rules illuminated the relation between teaching techniques and subject matter.

I remembered how I had been scandalized by receiving a high *A* in my unhappy introductory course in chemistry for memorizing the steps in soap making and iron smelting and translating them into chemical formulas without benefit of theoretical insight. I remembered the angered agony of my premedical college roommate when he was memorizing the six hundred formulas in his course in organic chemistry. I also remembered how a committee of the faculty at the University of Virginia had persuaded the member of the committee from the department of chemistry of the rightness of a curriculum for honors students, only to have him say at the end of his approving statement that his department could not participate because it would need more time and prerequisites than he could honestly recommend in a well-balanced course of studies, and that, furthermore, graduates from the honors course would not be sufficiently prepared to take up graduate work in chemistry.

My medical friend further argued that the liberal college should accept the historic fact that chemistry, whether it be alchemy or modern industrial magic, is a black art, the art of pouring, as its name indicates, which cannot be penetrated by the kind of intelligence that the liberal arts properly cultivate. Like communism, if taught at all in the liberal college, it should be presented as a sample pathology of the intellect, with the warning that many other dark things like it are loose in the world at present.

This therapy, or sentence of expulsion, for chemistry is harsh, but the diagnosis is true, or at least so it still seems to one outside the profession. To the philosopher, who has a vested interest in the liberal arts, and who cannot practice his arts at all if they are depressed, to whom in addition the aims and validity of the various scientific methods are things of special solicitude, the modern turn toward radical empiricism seems to have committed itself to many industrial arts that have not yet articulated their proper sciences. Chemistry seems to be an acute case of this; it has always borrowed its intellectual capital from other sciences in order to increase its equipment and its production of useful formulas. It is true that chemistry is not alone in showing this high ratio of art to science; the mathematics and physics with which it is often compared and on which it leans are themselves deeply involved in industrial enterprises that do not let the theoretical eye see what the operational hand does. If the liberal artist is right in accepting as his categorical imperative the proposition that knowing the truth makes men free, and if he is right that the transformation of operations into theory is his essential business, he must view with alarm the blind drift of all the natural sciences into operations that systematically refuse theoretical formulation. He finds the natural scientist perverse in refus-

ing to admit his responsibility for the theoretical foundations upon which he pursues his empirical enquiries, and rightly or wrongly he finds chemistry the going concern in the academic world that most powerfully threatens the common intellectual enterprise.

But in spite of the humanist's ignorance of modern science and the scientist's contempt for the stale liberal arts, the liberal artist cannot condemn chemistry with my medical friend. However incompetent he may be to face it, his assignment is cut out for him. He must accept the operations of the scientist as rational operations and find some way of transforming them into theory. If chemistry seems to be the darkest range of the intellectual spectrum, it may be the place to start the renaissance of liberal education and to expect a new birth of freedom in the world.

Chemistry as an art is not young; its theme of the transformation of substances is as old as civilization; whatever materials belong to the other arts belong also to chemistry, and more too; its practice continually served the farm, the workshop, the sick-room, the school, and the counting-house long before it served modern industry. Furthermore, its skilled operations have always reflected theory, and what is more important for the liberal arts, its operations have always contributed to theory. This suggests that there is light behind the dark aspect that chemistry presents to the liberal arts.

Modern industrial society, in coming to understand itself, has magnified one side of human nature in a way that no previous historic period has done. When we speak of the dignity of man, we now include the dignity of labor, the expression of his rationality in the work of his hands. In a new and spectacular way we know that man is a worker, a maker, a fabricator, an artist. No less than in his thoughts and his words, he is in his works only a little lower than the angels. In the old days this insight was given theological recognition in the doctrine that man was the product of a superartist, and his vital processes were understood as the operations of a reflexive artistry, a self-building. It was through an analogy with this human and divine art that all natural processes were understood. Now we think of society as the work of two great systems of arts, industry and politics, both of which increasingly depend upon the articulation of techniques into one system of technology. The secret of the new understanding of society that is being generated in this development is the notion of the tool or instrument. The tool has always been understood as a means of production, but an instrument is a tool that has become a means of knowledge; it connotes knowledge as well as skill. The Greek work for machine or mechanics had these two meanings, and it was the insight of the Greeks that made the beginnings of science in our culture. We are led to a new understanding of ourselves and our society by an emphasis on the technological system as a means of knowledge.

All tools have at one time or another been scientific instruments, and all science reflects and reflects on tools. Modern physics, which started in mechanics, reflects the lever, the wheel, the inclined plane, the screw, and their productive uses. Biology reflects hydraulic devices and their uses in investigating the subtle transformations of substances in the processes of assimilation, growth, and reproduction. Chemistry, developing between these two sciences, has always borrowed heavily from their arsenal of instruments, and it has contributed to them; but it has also borrowed liberally from their hypotheses, and has put them to characteristically unique uses; it has used them as instruments of investigation. Fire, at once a vivid experience and a useful agent in practical life, was also a great hypothesis for the ancients. It encompassed the world and held it together in a dynamic equilibrium. But in the spirit of chemistry the ancients used fire as an instrument to trace change and to detect and order the other elements, air, water, and earth. Fire assays, clarifies, and classifies the building blocks of the universe. At a later time the accessories of fire, the furnace, the retort, the alembic, and the crucible, distinguish and define the properties of the modern elements, and by a converse reflection the kinetic theory of heat penetrates to the form and structure of the molecule. With the help of the theory of gravitation the chemical balances give number, weight, and measure to the modern atoms. In the work of Faraday this use of the great hypotheses as instruments of investigation reaches its climax. It is impossible to tell whether he is developing the theory of electricity or discovering the constitution of matter; electricity, a new kind of fire, uncovers new properties of matter, and the chemical elements become the indices of the properties of electricity. Finally the superhypothesis of radiant energy is projected into the hypothetical heart of matter.

It appears from this that chemistry has a particular genius for reaching to the highest hypotheses in all the sciences and turning them to radical instrumental use, and, as a consequence, reduces everything in the universe to concatenations of reciprocal instruments, force to element, element to element, mineral to organism, organism to organism. The borrowed instrumental hypothesis revolutionizes the science from which it has been borrowed.

If this is a proper over-all view of chemistry, then there is a profound revolution in thought brewing in the crucible. Far be it from me to accuse the chemist of apostacy to the dogmas and habits of empirical science, but there is here all the appearance of a cosmology, the kind of speculation which is the special privilege of the philosopher. Furthermore, it appears to be a cosmology to which all the sciences contribute and toward which they are all drifting, a cosmology in which every item in the universe is functionally related to all other items in an instrumental reciprocity of means and ends. This outcome, if it can be entertained as such, translated into theoretical terms, if that is possible, would establish a new basis for all the sciences. It would provide a substantial ground for the formulation of homogeneous laws of nature in a single unified science of

nature. It would provide a long lost subject matter for analytic mathematics, and, since it would fully reflect technology, it would enable the social sciences to grasp the laws of society. It would formulate a new theory of natural law as a foundation for both science and morals. Through this new instrumental mode of thought, so thoroughly practiced but never preached by the chemist, the liberal arts might get a new lease of life.

But, as must be painfully recognized, this speculation is even philosophically irresponsible: I am predicting a new base of intellectual work, and although I can see its possible source, I do not know what it might be. I am sure that it is needed, and I have a strong hunch that it will come. The idea that it might come suggests a moral. There is a chaos in the republic of learning which is due to an intellectual chaos in the liberal arts. I am suggesting that part of the chaos is due to the degree to which operations have outrun ideas. All of the natural sciences show symptoms of it, chemistry more than most. Evidences of the disease are to be found in all the liberal arts. But the chemist, who is the yellow dog of the academy, is also a scapegoat for all of our intellectual sins. He has brought this upon himself, and he has little chance of finding a respectable place for himself in the genteel ways of the decadent humanists; I think it will be admitted that he does not want such a place. But all eyes are upon him. He has the free use of all the tools upon which the intellectual community lives and a free run of the practical world in which he is master mechanic. We all are following the scapegoat whether we like it or not. The question is: can the scapegoat become the savior of intellectual freedom in an industrial world? A savior might be defined as a person who cannot be tolerated in a community unless he brings revolution. In this case the chemist cannot be tolerated unless he revolutionizes the liberal arts, and thus brings an intellectual light to the whole human enterprise.

I once discussed this question with Selig Hecht who made a visit to St. John's College to see what we were doing in our laboratories. He respected our attempt to solve the basic problem I am discussing by teamwork in a faculty primarily devoted to teaching. He agreed with us in not viewing its outcome optimistically. He said the job would have to be done by top-flight scientists first, and that then the rest of us might again learn to teach. I can think of no higher authority to quote in support of my pessimistic, and, I hope, challenging remarks.

• KLAUS CLUSIUS

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KLAUS CLUSIUS, eminent physical chemist, was born at Breslau on March 19, 1903. He received the Dr. Ing. degree from the Breslau Technische Hochschule in 1928. A Rockefeller stipend allowed him to spend one year at Oxford under C. N. Hinshelwood and several months at Leiden where he worked under W. A. Keesom in the Kammerlingh-Onnes Laboratory. His teaching career began at Göttingen, where he habilitated in physical chemistry in 1931. He was called to Würzburg as associate professor in 1934 and after two years was appointed department head at Munich. He entered his present position, Director of the Physikalisch-Chemisches Institut at the University of Zurich, in 1947.

Professor Clusius has successfully devoted himself to a variety of research topics. His main fields of interest have been reaction kinetics, low temperature studies, and investigation of isotopes.

The work on reaction kinetics began in Hinshelwood's laboratory, with studies of homogeneous gas catalysis. Recently, particular attention has been given to flame reactions. The spreading and form of hydrogen flames at the lower explosion limit and the accompanying diffusion processes were explained with the aid of heavy hydrogen and "colored" flames. The radical change in the structure of carbon suboxide flames by drying is one of his newer discoveries.

The low temperature studies have dealt especially with specific heats, heats of transition, heats of fusion, and the entropy of condensed gases. The singular division of the transformation of methane CH_4 at 20° absolute into two transitions in the case of CH_3D and CD_4 was established. In other instances, such isotopic effects resulted in considerable shifts of the transition points of "deuterized" gases.

The separating tube process was discovered in 1938. It makes possible an enormous increase in the concentration shift of gaseous and liquid isotopes as compared with the slight effect achieved by thermodiffusion. The process was subsequently developed with the collaboration particularly of G. Dickel and H. Kowalski. By this means, for the first time Cl^{35} and Cl^{37}, Kr^{84} and Kr^{86}, O^{18}, and recently N^{15} were obtained at a purity of over 99 per cent. N^{22} and N^{20}, first separated by Hertz, could now be obtained by the liter.

Professor Clusius is a member of the Academies of Munich, Halle, and Bologna. In 1940 he was awarded the Arrhenius Prize of the University of Leipzig, and in 1943 he was the recipient of the Cannizzaro Prize of the Accademia dei Lincei in Rome.

A NOVEL INTRODUCTION TO ATOMIC STRUCTURE

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Festival of Britain Office, London, England

AN EXHIBITION of Science at South Kensington, London, forms part of the Festival of Britain this summer. Science, of course, appears in its "user setting" in almost all of the festival exhibitions, as well as occupying a unique place in the giant "Dome of Discovery" on the South Bank. In the Exhibition of Science, however, it is considered in its "pure" sense, *i. e.*, man's quest for knowledge into the structure of matter, both inanimate and biological. In common with all the scientific displays in the festival, accuracy of presentation and thematic balance have been assured by very close collaboration with almost all the leading scientists in Britain.

In order to introduce the public to the idea that matter consists of molecules and atoms, a novel entrance sequence has been designed; this is contained in five rooms with interconnecting corridors.

In the first room there is a pencil-lead writing on a piece of paper, all at natural size. Leaving this the public passes through a corridor in which they are told by loudspeakers that they are entering a wonderland where things grow larger and larger. To heighten the effect the ceiling rises and stripes on the walls get wider and diverge.

The second room contains the pencil-lead and paper magnified by a factor of ten—this scale increase being chosen to condition the public to what follows.

In the next corridor, which is fairly dark, the loudspeakers explain that the factor of magnification is now a thousandfold, *i.e.*, 10^4 times life size. The paper appears exceedingly rough and the tip of the pencil lead is seen with flakes of graphite sliding from it.

The speech in the third corridor is somewhat inhuman, an effect obtained by using a mixture of straight speech and speech in which the vocal chord sounds have been replaced by organ chords by means of a Vocoder. The public is prepared for another thousandfold scale increase and the fourth room shows the crystal structure of the graphite. This, of course, no longer resembles the original lead, but appears as the familiar hexagon pattern. Peaks and valleys in the structure signify the rough surface of the graphite.

The speech in the final corridor is as inhuman as is compatible with intelligibility, and it explains that the final room is at a magnification of $10.^{10}$ To heighten the effect of unreality, the floor is covered with "Dunlopillo" (rubber mattress material) and the room is in total darkness except for the actual display. This is a wave-mechanics representation of a carbon crystal, in which the probability of finding an electron at any place is translated into light intensity. The atomic nuclei appear as bright white spots in space; symmetrically round them are the spherical K shells shown as somewhat fuzzy clouds of blue light. The trigonal bonds connecting the appropriate nuclei are green clouds of light, while the π orbitals, protruding forward and backward, normal to the nuclear planes, are yellow clouds. Behind the first nuclear plane other nuclear planes can be seen stretching back to an apparent infinity. The dimensions of this display are 17 ft. by 7 ft., surely the largest wave-mechanics atom in the world.

The techniques used to produce the effects in this sequence have been the result of considerable research and development, and they represent a great advance on the usual ball and spoke models.

The display in the fourth room showing the crystal structure of graphite consists of a number of parallel sheets of plate glass normal to the observer. The crystal pattern, including the peaks and valleys, is built up by etching the atoms on the glass which is edge-lit. The atoms thus appear as tiny points of light, the structure being seen in three dimensions.

The final room, with the wave-mechanics crystal, is somewhat similar in construction. Instead of glass, "Perspex," the British trade name of transparent acrylic resin, is used. Twenty parallel sheets, each 17 ft. by 7 ft. are placed between a semisilvered mirror at the front and a fully silvered mirror at the rear—these parallel mirrors producing the repeating pattern of nuclear planes. The nuclei consist of small hemispheres cut in the Perspex and filled with white phosphors. The "probability clouds" are sprayed onto the sheets in colored phosphors, the multiplane construction permitting any three-dimensional pattern to be built up. The entire display is illuminated from the top with ultraviolet light—thus producing the glowing clouds of color. Perspex is used instead of glass on account of its high transparency to ultraviolet light, any fire risk being minimized by the fitting of automatic sprinklers in the ceiling.

The rest of the exhibition following this initial sequence demonstrates, in as dynamic manner as possible, our present knowledge of structure. Starting with change of state and Brownian motion as commonsense evidence of the existence of molecules, it continues with the breakdown of everyday objects into elements and then into atoms. The main circulation shows how the concept of stable electron shells explains how compounds are built up; this theme is carried through to more complicated organic chemistry including synthesis. The chemistry of proteins forms the

link to biological structure. Supplementary circulations trace the structure of light, of crystals, and of metals, while another section is devoted to atomic physics from the discovery of the electron to nuclear fission.

The biological section, "Living Structure," shows how the cell is the fundamental unit and how cells are put together to form the most complicated organisms. Reproduction and genetics form part of this story, as well as examples of cells that have "gone wrong" and resulted in cancer.

The final part of the exhibition, called "Stop Press," deals with some of the latest research that is engaging the attention of scientists. The subjects chosen for this section are: sensory perception, electrons in crystals, the physical and chemical approach to the problem of life, electronic computers, cosmic rays, and the formation of the universe. This last subject, which forms the finale of the exhibition, demonstrates the Hoyle theory by means of five dynamic models, ending with the expanding universe and continuous creation of matter—a fitting climax to the exhibition.

"AS I KNEW MICHAEL FARADAY"[1]

JAMES R. IRVING
Pure Oil Company, Crystal Lake, Illinois

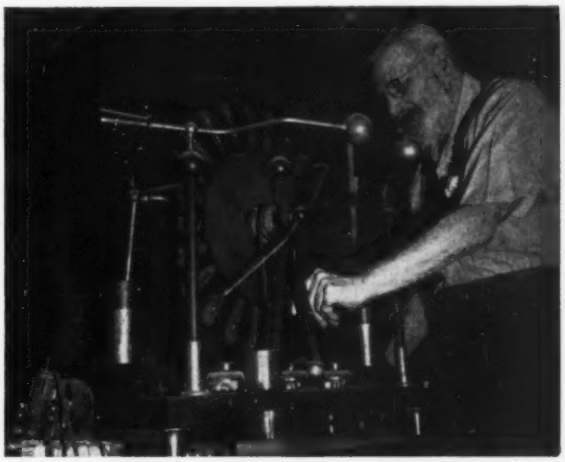
The scientist should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biased by appearances; have no favorite hypothesis; be of no school; and in doctrine have no master. He should not be a respector of persons, but of things. Truth should be his primary object. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of nature.
Michael Faraday

"MICHAEL FARADAY? You bet I can tell you something about Mike—all the men in the laboratory called him that, you know." It was 93-year-old Robert William Vicarey talking, one time bottle washer and handy boy for the great English scientist in his laboratory at the Royal Institution, London.

"Faraday married my grandmother's cousin and took me into his home and laboratory at the age of nine. There wasn't much that a lad of nine could do in a laboratory, but Mike set me to work washing bottles."

Vicarey quickly explained that bottles, in those days, were actually clay containers. And he well remembers an occasional box on the ear he received at the hand of Faraday when he "accidentally" dropped one. Faraday's admonition, however, was never more than, "Come on. Wake up, boy."

An almost holy reverence still envelops 93-year-old Vicarey when he recalls other incidents which occurred during his association with "Mike." It goes without saying that his own life was thoroughly influenced by this intimate contact with the great English scientist. His more than 75-year career and study as a traction battery scientist serve as evidence. Faraday's love for experimentation, too, has influenced the man to this day. An entire second floor of his Milwaukee, Wisconsin home is completely devoted to electrochemical investigation (see Figure 1).

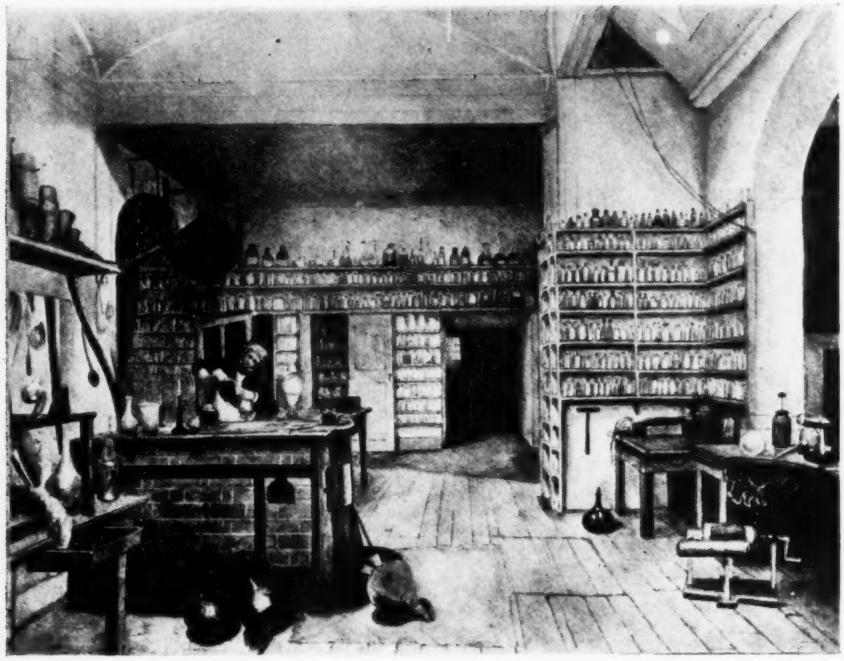


Milwaukee Journal Photo

Figure 1

A far cry from the glass globe apparatus of Faraday's laboratory. Mr. Vicarey adjusts the electrostatic machine he built preparatory to an experiment. This equipment is a part of his home laboratory.

[1] Based upon an interview and selected notes of Mr. R. W. Vicarey.



Fisher Scientific Co. Photo

Figure 2. Faraday's laboratory in 1868

I was never able to make a fact my own without seeing it; and the description of the best works altogether failed to convey to my mind such a knowledge of things as to allow myself to form a judgment upon them. It was so with *new* things. If Grove, or Wheatstone, or Gassiot, or any other told me a new fact, and wanted my opinion either of its value or the cause or the evidence it could give on any subject, I never could say anything until I had seen the fact. For the same reason I never could work, as some Professors do most extensively, by students or pupils. All the work had to be my own.[2]

Volume upon volume of Vicarey's notes emulate "Mike's" pious devotion to the accurate recording of all his experiments.

I already owe much to these notes and think such a collection worth the making by every scientific man. I am sure none would think the trouble lost after a year's experience.[3]

[2] Faraday's writings.

[3] From one of Faraday's notebooks, 1822.

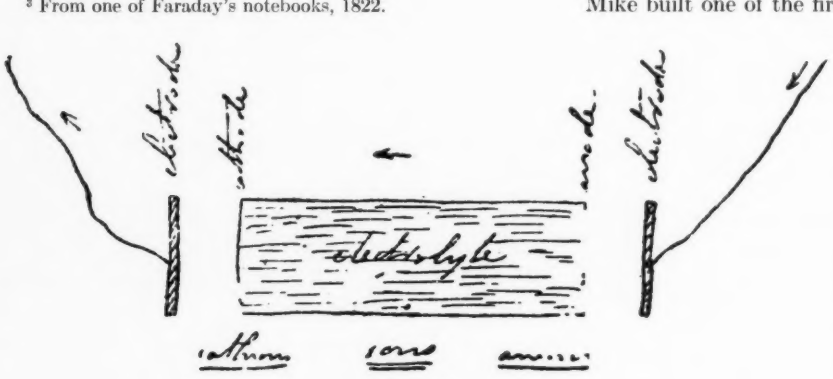


Figure 3

But more about Faraday, the man. He was always a gentleman. Michael Faraday's deep aversion to knighthood for his many contributions to the world of science, a coveted honor for most English scientists, did not lessen Queen Victoria's deep appreciation and admiration for him. In his later years, with his health broken by overwork, the Queen gave him lodging and complete care at Hampton Court Palace near London.

"Faraday," continued elderly Mr. Vicarey, "in all his worldly contacts was a typical Sunday School boy. He was 'strictly religious' and did not use tobacco in any form. He had a fondness for wine, but always used it with the greatest of discretion and good taste."

As the story of Faraday's life unfolded from the memory of one who formerly worked in his laboratory, the English scientist's complete humility and deep respect for his fellow men seemed to characterize his every waking moment. Vicarey summed it up like this: "Faraday sat on his dignity."

The old man's hand pointed to a picture on the wall of his study showing Faraday working in his London laboratory. "Many's the time I trimmed the wicks of the candles for him. We didn't have gas burners, then, you know. My other chores around the laboratory included turning the glass globe electrostatic machine [shown in the lower right hand corner of Figure 2] and pumping the blacksmith's bellows."

"He was always investigating things," continued the old man. "He really never completely stopped working. It's never been published to my knowledge, but Mike built one of the first modern diving bells." Mr. Vicarey stroked his neatly trimmed, white beard. He said he was on the shore of the River Thames with Faraday during the early trials of the equipment.

According to Vicarey, as the story went around the laboratory in those days, Michael Faraday was quietly eating lunch next to his bench when he first observed the principle of electromagnetic induction. He jumped to his feet to make

sure his eyes were not deceiving him. They were not. The great industrial world of the electric motor and the generator was born from this historic observation of a moving coil of wire around a magnet. The old admirer of Faraday reflected, "One could truly say it was not the moving coil that was the turning point in our industrial and engineering history but the interpretation of its meaning by the man who watched the wire turn."

It almost sounds as if Faraday came upon many of his discoveries by chance, but his former handy boy would strenuously disagree with this conclusion. Kohlrausch, a German contemporary of Faraday, gave a better evaluation of the man's talents, "Er riecht die Wahrheit."

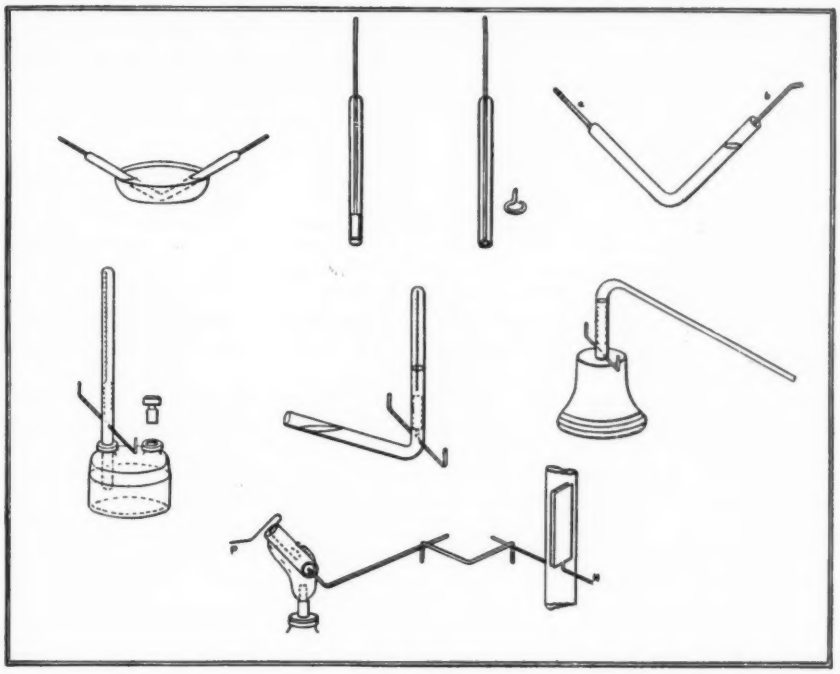


Figure 4

Vicarey borrowed from Faraday's own writings to sum up the English scientist's secret of success as a scientific worker. "The secret is compounded in three words—Work, Finish, Publish."

The old man delighted in reviewing the many contributions of his English idol. "Yes, the world acknowledges Faraday as the father of electrochemistry, a pioneer in electromagnetic induction, and discoverer of benzene; but his active mind covered much more ground than that. His 'Chemical Manipulation' of 1827 outlined fundamentals of laboratory technique that were to guide chemists to this day. [This included a practical method to obtain distilled water.] He was the first to adapt cut-sheet rubber for tubing and to experiment with gases. He probably was the first to recognize the anaesthetic effect of ethyl ether. He contributed a paper on its properties to the *Journal of Science and Arts* in 1818 which noted that 'when the vapor of ether is mixed with common air and inhaled, it produces effects very similar to those occasioned by nitrous oxide.' "

It was Faraday who first introduced the terms "ion," "cation," and "anion." His scientific desire to avoid all terms tainted by a foregone conclusion prompted him to consult with W. Whewell of Trinity College, Cambridge, in 1834 who suggested them after carefully considering the exact meaning Faraday wished to convey. Figure 3 is a reproduction of the original sketch by Faraday introducing the nomenclature of electrolysis in 1834.

Figure 4 shows his own sketches of the various "voltameters" he designed and presented in a paper published in *Philosophical Transactions*, 7th Series, January, **1834.**

Best of all, Mr. Vicarey likes to recall what he believes to be one of the finest tributes ever paid to Faraday. It came from Faraday's eminent teacher and a titled English scientist in his own right, Sir Humphry Davy. It was in his later years that he magnanimously acknowledged that his *greatest* discovery was Michael Faraday.

A Canadian steel company can boast of having shipped 30,000 pounds of "hot steel" and with the full approval of the law. In one of the most unusual operations of its kind ever attempted, a 30,000 pound steel ingot, at 1700°F., was shipped 200 miles in an insulated cast iron box, bolted to a railway car. There was a heat loss of only 125°. This method of shipping, not only saves weeks of time in cooling and reheatings, but eliminates the danger of ingot cracking while cooling.—*The Ohmite News.*

HOLD THAT FLAVOR[1]

RODERICK K. ESKEW[2]
Eastern Regional Research Laboratory[3], Philadelphia, Pennsylvania

IT IS a deep-rooted human instinct to grasp and hold the fleeting things of life. We fix a loved one's image on canvas or gelatin; we record the short-lived notes of a symphony and preserve a flower in impervious plastic. So, too, men have long tried to capture and thus prolong the enjoyment of the aromas of fresh fruit. This has now become a practical reality through research at the Department of Agriculture's Eastern Regional Research Laboratory in Philadelphia.

In 1944 two young chemical engineers, H. P. Milleville and E. L. Griffin, Jr., for the first time captured, in concentrated unaltered form, the volatile aroma of fresh apple juice. Their success can be largely attributed to a new approach. Most previous investigators had attempted to capture the aroma when concentrating the fruit juice under vacuum. Quite logically, vacuum was used to avoid heat damage to the juice or the aroma. However, consideration of the problem from a theoretical viewpoint showed that the losses in aroma from the vent gases of any volatile flavor recovery system would be almost inversely proportional to the absolute pressure in the system. They therefore abandoned the vacuum method and designed an apparatus to operate at atmospheric or higher pressure.

Their first process entailed heating the freshly pressed juice to about 320°F. in 3 seconds and then flashing it to atmospheric pressure. This vaporized about 10 per cent of the juice, which previous investigators had shown to be adequate for the release of all the aroma. The vapor passed to a fractionating column, where the aroma was concentrated to 100 or more times its concentration in the juice. Vent gases were scrubbed with the chilled product for more complete recovery. The resulting product was termed apple essence, since it contained the essential flavor ingredients characteristic of apples. This process was described by H. P. Milleville and R. K. Eskew.[4]

The apparatus would have had limited commercial value, however, because the tube in the superheater in which the juice was brought to the flashing temperature fouled rapidly, necessitating frequent shutdowns for cleaning. This drawback was overcome by substituting a rapid evaporator for the superheater. This innovation made the process commercially practical. It was described in a supplement to AIC-63. A later publication by Milleville and Eskew[5] describes the process essentially as it is carried out today.

The original object of this work was to obtain the volatile aroma of apple juice in such concentrated form that when added to a concentrate made from the stripped juice the product would have a high enough sugar content to prevent fermentation. This was achieved, and the product was termed full-flavor concentrated apple juice. It was soon apparent, however, that there were other uses for apple essence, for example, in enhancing the flavor of frozen concentrates, carbonated beverages, jelly, candy, ices, etc.

The new process met with enthusiastic response on the part of industry, and commercial development was expanding rapidly when it was found that the essence contained ethyl alcohol in sufficient quantity to be taxable. Ethyl alcohol is a component of apple flavor, and when the flavor is concentrated, the alcohol is increased enough to exceed the taxable limit of 0.5 per cent. This dampened the enthusiasm of industry for a while, but in September, 1949, the tax on volatile fruit concentrates, as essences are now termed, was removed. Thousands of gallons of volatile fruit concentrates made by the process developed at the Philadelphia Laboratory are now being produced and the new industry is expanding.

Volatile fruit concentrates are not confined to apples. The Laboratory also showed that the basic principles of the apple essence process could be applied to the juices of many other fruits, such as Concord grapes, blackberries, black raspberries, and strawberries. Now the essences of many fruits besides apples are being produced commercially.

Anyone who has been in the kitchen when preserves, jams, or jellies are being made knows that the air of the kitchen is pervaded with the aromas of cooking fruit. True, these are different from those of the fresh fruit, but they are pleasing and potentially valuable. The Eastern Regional Research Laboratory is currently studying the recovery in concentrated form of the aromas given off during the commercial manufacture of jams, jellies, and preserves. These recovered aromas should enhance the flavor of the finished product and may find use in other foods and beverages.

The astonishingly rapid growth of the frozen concentrated orange juice industry may encourage the

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[1] Report of a study, certain phases of which were carried on under the Research and Marketing Act of 1946.

[2] Head, Chemical Engineering and Development Division.

[3] One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, United States Department of Agriculture.

[4] MILLEVILLE, H. P., AND R. K. ESKEW, "Recovery and utilization of natural apple flavors," U. S. Dept. Agr., Bur. Agr. and Ind. Chem. AIC-63, Sept. 1944. (Processed.)

[5] MILLEVILLE, H. P., AND R. K. ESKEW, "Recovery of volatile apple flavors in essence form," Western Canner and Packer, Oct. 1946.

market development of other frozen juice concentrates. Where do fruit essences fit into this picture? Using essence from eastern varieties of apples, the Philadelphia Laboratory has made frozen concentrated apple juice which, when diluted with water, yields a product with all the flavor and aroma of the fresh juice. At the Western Regional Research Laboratory in Albany, California, essence from western varieties of apples has been similarly used. Employing grape essence, the Philadelphia Laboratory has also prepared frozen concentrated Concord grape juice. When water is added, the product is comparable in quality with the highest grade bottled grape juice.

Several research laboratories of the Bureau of Agricultural and Industrial Chemistry are studying various aspects of recovery of the volatile flavors of fruits grown in their respective regions.

The frozen orange concentrate now on the market is a high-grade product, and public acceptance has been enthusiastic. Could that product not be still better if orange essence were used to contribute the characteristic orange aroma to the product instead of a small amount of fresh orange juice as is now used? This possibility will not be overlooked in the research program of the Bureau of Agricultural and Industrial Chemistry.

QUICKER STEAM-BATH EVAPORATIONS

GEORGE E. ROUSE
Ottawa University, Ottawa, Kansas

ONE of the big headaches of the analytical chemist has always been the slowness of evaporations when they must be accomplished quantitatively on the steam bath. Where, by boiling, a solution may be evaporated to dryness with splattering in a relatively few minutes, its careful evaporation on the steam bath requires several hours. The main reason for this slowness is the fact that the heat of the steam bath is applied only to the bottom of the solution. If steam could also be applied to the sides of the solution, it is reasonable to expect that such evaporation would be much more rapid.

Therefore, "surrounded evaporations" were checked against the ordinary type of steam bath evaporation. Since steam as ordinarily confined in a bath is approximately as hot as boiling water, two types of evaporation were checked against the conventional method. In one, all but the top half inch of outer surface of the beaker was surrounded by steam only, while in the other, the bottom of the beaker was allowed to dip into the surface of the boiling water and the remaining outer surface of the beaker except the top half inch was surrounded by steam. Various volumes of natural salt water—density 1.0051—were timed for evaporation. The steam bath was of the constant level type and the water was heated to near boiling before the solutions were placed in position.

For the water-steam surrounded method 800-ml. beakers were used, while for the steam surrounded method 400-ml. beakers sufficed. In each case similar-sized beakers containing like amounts of solution were evaporated conventionally. All beakers were covered with watch glasses supported by glass hooks. Only beakers of the size mentioned were used as they were the only ones which would pass through the steam bath rings and form a nearly steam-tight fit. The accompanying table gives some results of such tests.

Times for Evaporation

	400 ml. beaker		*800 ml. beaker*	
Ml. salt sol.	*Surrounded by steam, min.*	*Conventional, min.*	*Surrounded by boiling H_2O and steam, min.*	*Conventional, min.*
50	66	102	48	64
100	263	330	118	268
200	383	568	184	381
Av. time/ml.	2.03	2.86	1.00	2.04

From the above results we see that surrounding by steam only reduces the time of evaporation by approximately 29 per cent. When the bottom of the beaker is in the boiling water and the remainder surrounded by steam the time is reduced approximately 51 per cent. It was also found that the air currents in the room had considerable effect on the rate of evaporation, especially that of the conventionally evaporated solutions. More tendency for the salt to crystallize on the sides of the beaker was noted than in the conventional method.

To make this method generally applicable, new covers, designed to fit the various sized beakers, would have to be made. The beakers may be supported by hanging by the lip, or, better, a perforated false bottom of stair-step construction may be built inside the bath. Such steps should be so adjusted that each will allow a given size of beaker to set on it, the beaker's lip just clearing the cover. For convenience in cleaning, the false bottom should be removable.

RUBBER PLUS CHEMISTRY[1]

HARRY L. FISHER
National Research Council, Washington, D. C.

THE expression, "Rubber plus chemistry" is in typical chemical language. Perhaps I should add to it, "equals what?" Suppose I try to make a real equation of it. Then the "what" becomes a multitude of answers; in fact, as in organic chemistry the equation is seldom simple, since an organic reaction generally leads to many things. That is one reason why it is so interesting. This paper is an attempt to present some of the answers.

Rubber *minus* chemistry was making a little headway in the early part of the last century, 150 years ago. Even as early as 1791 Samuel Peal in England obtained the first known rubber patent, a patent for the waterproofing of fabrics. Also, raw rubber was known for its property of rubbing out pencil marks—whence its name. Nevertheless, it must be remembered that the name, contrary to some statements, evidently had been given it before Priestley in the preface of one of his books (1770) wrote, "I have seen a substance excellently adapted to the purpose of wiping from paper the marks of a black lead pencil." He recommended its use "to those who practice drawing," and told where it could be bought. Natives in South America made rubber overshoes by dipping clay forms into latex. Five hundred pairs were imported from Brazil into Boston in 1823 and sold.

Thomas Hancock in England cut strips of rubber from imported raw rubber shoes and bottles for use in making tobacco pouches and elastic fabric containing threads of rubber. In a patent, "Enrolled August 8, 1820," he describes how he applies his "caoutchouc spring," that is, elastic fabric, for use "in the wrist of the glove," and "the mouth of pockets, to prevent their contents from falling out when in an inverted position, and to prevent their being easily picked; . . . to braces, instead of wire and other springs, . . . to stockings, to prevent their slipping down the leg; . . . to wigs, fake curls and fronts, to keep them tight on the head"; and for many other purposes. Hancock had plenty of imagination. In order to use up his waste cuttings, it occurred to him that, "if minced up very small, the amount of fresh-cut surface would be greatly increased, and by heat and pressure might possibly unite sufficiently for some purposes." He "thought that a tearing action might do better than simply cutting." The machine he made for this purpose consisted of a spiked roller that revolved in an internally spiked hollow cylinder, which was the forerunner of masticators, because cuttings worked in it "came out a round solid ball." He continues in his "Personal Narrative," "I wish here to remark that the discovery of this process was unquestionably the origin and commencement of the india-rubber manufacture, properly so called." This was in the summer of 1820.

Masticated rubber increased its usefulness a great deal both as solid rubber in sheets, thread, etc., and also by means of solutions. Charles Macintosh in 1823 invented his double-texture garments and shortly Hancock used his solutions similarly. At this same time Hancock obtained a British patent for saturating fabric with rubber latex.

In 1828 Johann Nepomuk Reithofer in Vienna took out a patent for making elastic fabric containing rubber thread cut from raw rubber, and in 1829 a similar process led to the founding of the first German factory for making elastic fabric in Finsterwalde near Berlin.

In 1833 the Roxbury India Rubber Factory was established in Roxbury, Massachusetts, the first company organized in this country, to manufacture clothing, shoes, and other articles. Three years later Edwin M. Chaffee obtained a United States patent for the application of undissolved rubber to cloth and leather and for the processing machinery, which was the friction calender.

Charles Goodyear, a hardware merchant and an inventor, the son of Amasa Goodyear, a Connecticut hardware merchant and inventor, became interested in rubber, as he tells us in his book, "Gum Elastic," when "he was passing the store of the Roxbury India Rubber Company, in New York, and stopped to make inquiry about life-preservers, with the view of purchasing one." Later he returned with an improved tube for inflating life-preservers, and "being pleased with his success in that, the agent advised him to turn his attention to the improvement of India rubber, and said, in behalf of the company, he would insure a very large compensation to any one who would overcome the great difficulties they met with in the manufacture, which were, great adhesiveness and subsequent decomposition of the goods."

Goodyear soon learned of the difficulties encountered by others, especially that "India rubber manufacturers had always been careful to avoid a heat of more than 100 degrees of Fahrenheit in the manufacture of their wares; and in the case of the Macintosh goods, their circulars cautioned customers not to approach too near the fire with them." In his attempts to get rid of the adhesiveness of rubber he became much elated with the combination of rubber and magnesia. The magnesia appeared to dry the rubber just as other substances dry paints. Of especial interest was the fact that the rubber product was white whereas manufactured rubber goods were all black. Several years later he wrote, "A

[1] Address at the Dedication of the Knight Chemical Laboratory, University of Akron, Ohio, January 18, 1951.

book was bound with this compound in 1834, the cover of which softened and fermented at that time, but is now hard as shell."

That rubber had been brought into rather extensive use, especially in England, before the discovery of vulcanization, is shown by Hancock's statement "that we were frequently using from three to four tons a week, as early as 1837 and 1838," that is, 150 to 200 tons a year. This was in spite of "its original objectionable qualities, namely, its clamminess, its tendency to stiffen and harden, and consequently to lose its elasticity, by cold; to be readily softened and decomposed by heat; and to be rendered soft and, as it were, rotten by grease and oils." Thus did Professor Brande sum them up in a series of lectures on organic chemistry before members of the Royal Institution. Its "clammy adhesiveness" was removed by the addition of magnesium silicate (talc), and later "The other objectionable properties are subdued by the extraordinary influence of sulphur."

It may be well to mention that while the rubber business was flourishing in this country in the early 1830's, 540 long tons of crude rubber were imported in 1834, but because of serious difficulties and complaints, the business dwindled and in 1840 only half the amount above, 260 tons, were imported. Vulcanization, discovered in 1839, definitely revived the industry as indicated by the imports in 1845, 400 tons; 1850, 615 tons; and 1855, 2150 tons. From the standpoint of a century later these figures are very puny but there were no automobiles then and also the population was much smaller.

CHEMISTS BEGIN STUDY OF RUBBER

In the meantime chemists were slowly becoming interested in this unique elastic material. One of the first was Michael Faraday who was a chemist as well as a physicist. In a beautifully written article published in 1826, he describes how he purified the rubber hydrocarbon from latex received in bottles from Mexico, and by analysis affirmed that it is a hydrocarbon with the carbon-hydrogen ratio of 5 to 8. Others used the methods in vogue at the time and besides making analyses they destructively distilled or pyrolyzed it. Among these workers was A. Himly, who, in his dissertation at Göttingen, 1835, describes two hydrocarbon fractions thus obtained, the lower boiling of which he called "faradayin" and the higher boiling "caoutchene." Fifteen years later, from a similar low-boiling fraction, C. Greville Williams isolated a substance which he named isoprene. He also noted that on standing the isoprene became viscous, and this viscous liquid, on fractional distillation, was converted in part into a "white, spongy, elastic mass similar to rubber."

Chemical derivatives of rubber had been sought early in the century, the action of chlorine on rubber in solution being studied in 1801 by Roxburgh, although the first definite production of chlorinated rubber was probably by Engelhard and Day in 1859. J. Spiller, in 1865, undertook the earliest recorded work on the oxidation of rubber, and histories of oxidation of rubber all speak of Spiller's resin.

Charles Goodyear, in his attempts to make rubber articles that would last, heated rubber with lime and then used bronze powder on the surface of the goods. He did not like the effect, and in dissolving away the metal powder with nitric acid he discovered that the surface of the rubber lost its adhesiveness. This "acid gas process" was interesting but only affected the surface of the rubber. To obtain data for a patent, he "came near being suffocated by generating a large quantity of gas in a close room; he, however, escaped with a course of fever." Evidently the gas consisted of nitric oxides, and he was a lucky man.

SULFUR

In 1832, F. W. Luedersdorff of Berlin found that when rubber is dissolved in turpentine containing sulfur in solution, the rubber that was obtained after evaporation of the solvent lost its adhesiveness. Jan van Guens of Haarlem, Holland, similarly used turpentine solutions of rubber and sulfur. The time was ripe for something to happen; for a new discovery.

The use of sulfur was really not entirely new even with these chemists and inventors. If it is desirable to go further back in time, then it should be mentioned that South American Indians coated fabrics with latex mixed with gunpowder which contained sulfur, and let them dry in the sun. The rubber in one of these coated fabrics years later was found to have a total of 1.57 per cent of sulfur, 0.9 per cent of combined sulfur. And, to go still further back in time, in certain lignite mines in Germany the so-called monkey hairs are the fossil remains of rubber latex from twigs of a very ancient plant, and in some of the mines the hairs have been vulcanized by means of migrated sulfur, some as soft rubber and some hard.

In this country, in 1838, Charles Goodyear became acquainted with Nathaniel Hayward who had been superintendent of a rubber factory in Woburn, Massachusetts, and who had used sulfur in and on some of his compounds and had exposed them to the sun's rays to "dry" the surface, a process called "solarization." Goodyear learned of these methods and also that Hayward filtered his turpentine through sulfur. On Goodyear's insistence and with his help, a patent was taken out in Hayward's name and assigned to Goodyear. Thus Goodyear began to use sulfur in his compounds of rubber, even using it in combination with his acid gas process, to make life-preservers, beds, cushions, carriage cloths, shoes, mailbags, and tents. Then came final apparent approval from an unexpected source—a government contract for a considerable quantity of mailbags, a fateful order full of significant and very important results. The rubber on the fabric contained chiefly sulfur and white lead.

Unfortunately for his immediate financial condition but fortunately for posterity, the mailbags, "being finished in the warm season," and after purposely having been hung up for testing, "were discovered to be decomposing, and to be dropping off the handles." Poor Goodyear. Again, another process proved to be

a complete failure. "Instead of realizing the large fortune, which, by all acquainted with his prospects, was considered certain, his whole invention could not bring him a week's living. Again he saw those dear to him, together with his aged parents, stripped of the comforts with which they were surrounded. Every thing that he possessed was brought to the hammer for the discharge of private bills." Furthermore, "It was generally agreed that the man who could proceed further in a course of this sort, was fairly deserving of all the distress brought upon himself, beside being justly debarred the sympathy of others." "Frequent visits to the factory at Woburn became necessary, for the purpose of closing up and discontinuing the manufacturing operations at that place. . . . While on one of these visits . . . and at the dwelling where he stopped whenever he visited the manufactory at Woburn, the inventor made some experiments to ascertain the effect of heat upon the same compound that had decomposed in the mail-bags and other articles. He was surprised to find that the specimen, being carelessly brought in contact with a hot stove, charred like leather."

It is well to stop a moment at this point in discussing the discovery of vulcanization to give the facts as Goodyear himself gives them in his book, "Gum Elastic," because there have been many unfortunate variations of it. He didn't just drop a lump of sulfur and rubber on a hot stove, or a lump of sulfur into some hot melted rubber. Also, it is unlikely that he promised his wife that he would do no more experimenting, and then while she was out broke his promise and on hearing her returning threw his samples into the stove, and later found the one containing sulfur had become vulcanized. He wasn't even at home when he made his great discovery.

The real facts are different. Of all the rubber heresies, he decided to ascertain the effect of heat and was surprised to find the specimen, being carelessly brought in contact with a hot stove, charred like leather. It didn't melt and become sticky as he and others had so often learned; it charred. He repeated the experiment carefully with a "similar fabric," probably a piece from one of the mailbags, and noted that "upon the edge of the charred portions of the fabric, there appeared a line, or border, that was not charred, but perfectly cured." His use of the word "carelessly" could be interpreted to show that it was a careless experiment, but I believe he meant that he was careless in the manner in which he performed the experiment. It should be mentioned also that his samples contained fabric—rubberized fabric, and therefore not stretchable.

His discovery was far greater than he dreamed because it has continued to this day to be the mainstay of our great rubber industry.

Was Charles Goodyear a chemist or just a mixmaster? Well, what is a chemist anyway? By definition, a chemist is "one versed in chemistry," and chemistry is "the science that treats of the composition of substances, and of the transformations which they undergo." If this is the case, where can the line be drawn to distinguish an ordinary experimenter from a chemist? When does one become the other? May it not be well to include in the definition of a chemist one who uses chemicals to such good advantage as to produce new and useful products? If this is acceptable, then how about Goodyear? He used chemicals for several years before he discovered vulcanization. The record shows that a druggist friend "supplied drugs as were necessary for his experiments," and at one of the many times he was in need of money, he pawned a book on chemistry, but apparently only after he had pawned many other things. He did not claim to be a chemist. He wrote, "While the inventor admits that these discoveries were not the result of *scientific* (italics are his) chemical investigations, he is not willing to admit that they were the result of what is commonly termed accident; he claims them to be the result of the closest application and observation." This sounds like a research chemist. In fact, I am sure that any of our modern research chemists, even with a Ph.D. degree, would be tickled to have to his credit a discovery as important as vulcanization.

THE MODERN CHEMIST DISCOVERS RUBBER

From the time of the discovery of vulcanization to the early years of this century practically all the improvements in the manufacture of rubber were mechanical. It is true that Thomas Hancock in England rediscovered vulcanization after studying samples sent to England by Goodyear, Alexander Parkes discovered the use of sulfur chloride as a vulcanizing agent for thin films of rubber, lime, magnesia, and litharge became inorganic accelerators, considerable chemical work was done on the reclaiming of vulcanized rubber, and some observations were made on the polymerization of isoprene to rubber-like products.

A glance at chronologies and the literature of rubber shows how meager were the works of chemists during all these years. Such lack of attention was not alone in the rubber industry—it was generally true of all industries. Then came the chemical awakening. Chemists began to do things. Their work was autocatalytic. Organic accelerators, antioxidants, reinforcing agents, vulcanization with nonsulfur chemicals, vulcanization of latex, electrodeposition of rubber, chemical derivatives of rubber, the chemical structure of the rubber hydrocarbon, retarders of vulcanization, methods of chemical analysis—these and more are familiar because they have happened so recently. Then, too, there are the synthetic rubbers, thiokol, neoprene, Buna, Buna-S, Buna-N, Hycar, Chemigum, Butaprene, butyl, GR-S, silicone rubbers, and others. What a synthetic march they make!

The chief faults of raw rubber had been overcome by vulcanization, but vulcanized natural rubber still suffers from comparatively poor aging, especially with ozone and sunlight, and ozone from the coronal discharge; swelling and decomposition with oils and solvents and highly corrosive chemicals; too short a range of practical temperatures; inflammability (witness the

recent disastrous Chicago fire); high gas permeability; objectional odor; relatively high water absorption; and reversion.

Some properties were enhanced to great advantage by the action of added organic ingredients, but the greatest recent advances in the rubber field have been made with synthetic rubbers. Thiokol has the greatest resistance of all the rubbers to the swelling action of gasoline, benzene, and oils, has greater resistance than natural rubber to the action of sunlight and ozone, and is lower in permeability to gases. In comparison with natural rubber, neoprene, which is more like natural rubber than the other synthetics, is more resistant to the action of oil, sunlight, ozone, oxidation, and heat, and is more flame resistant. The nitrile rubbers show higher resistance than natural rubber to oil, gasoline, and aromatic solvents, and to heat. Low-temperature GR-S has higher resistance to abrasion and therefore gives better treadwear, is less affected by heat, and has lower water absorption. Butyl rubber is much more resistant to attack by highly corrosive chemicals, to swelling by many organic solvents, and to the deteriorating action of weather aging, including sunlight, oxygen, and ozone; it has less permeability to gases than natural and any of the other synthetic rubbers. Polyacrylic ester rubbers are more resistant than natural rubber to ozone, heat, gas diffusion, and certain solvents. The silicone rubbers have the widest temperature range of all the rubbers, natural and synthetic, from approximately $-100°F.$ to $+500°F.$ They also are more resistant to weathering than natural rubber.

Synthetic rubber compounds in general show greater heat build-up—that is, higher hysteresis loss—than natural rubber compounds. This difference between natural and synthetic rubbers is the last to be cut down and eliminated. Synthetic rubbers have been made, but only in small quantities, that have hysteresis values equal to and even lower than natural rubber. Now it appears only a matter of time until these will be available in larger quantities for further study. When this has been accomplished the last stronghold of natural rubber will have been conquered.

A METHOD OF PREPARING OXYGEN

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SEVERAL years ago I became dissatisfied with the usual method of preparing oxygen in the laboratory, that of heating a mixture of potassium chlorate and manganese dioxide. That there is some danger in performing this experiment is evident from the fact that there have been, in recent years several reports of injuries to students from explosions. I once had a student who mixed potassium chlorate and manganese dioxide, as directed, and also included sulfur and charcoal which was to be used in testing the gas produced. Fortunately the student was not injured by the resulting explosion.

My principal objection to the above method, however, is that few students can control the heating of the mixture in the test tube sufficiently well to avoid producing a white cloud in the collecting bottles. In spite of the fact that their observation of the air about them shows oxygen to be invisible and colorless some students identify the white cloud in the bottles as oxygen. For these reasons I have for several years used the method described below.

The ordinary hydrogen generator is used. A teaspoonful of manganese dioxide is placed in the generator bottle with about 20 ml. of water and the bottle is rotated to mix the contents. Superoxol, 30 per cent hydrogen peroxide, is diluted to 6 per cent with water. The hydrogen peroxide is poured, as needed, into the thistle tube. The reaction is easily controlled, and the gas produced is colorless. Unless a student is careless and allows much gas to escape when changing bottles, 50 ml. of the 6 per cent solution should easily produce four 250-ml. bottles of oxygen. The action of manganese dioxide as a catalyst is just as well demonstrated by this experiment as with the conventional method. It is somewhat more expensive than the conventional method.

The use of potassium chlorate and manganese dioxide is later demonstrated by the following method. Two tubes are clamped so that the bottoms of the two can be heated equally by a burner flame. One tube is supplied with a small quantity of potassium chlorate and the other tube with a mixture of the chlorate and manganese dioxide. Testing with a glowing splint shows which produces oxygen first. A tube of manganese dioxide alone is then heated and tested in a like manner to show that no oxygen can be obtained from that chemical by the heat of a Bunsen burner flame.

The above demonstration serves also as an excellent project for an ambitious student. Ask the student to find out how many of the oxides found on the laboratory shelves will serve as a catalyst for the decomposition of potassium chlorate. The results may surprise even the teacher.

A SIMPLIFIED CONSTRUCTION FOR VACUUM DISTILLING APPARATUS

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CONTROLLED vacuum distillation with provision for taking several fractions is one of the most valuable methods available for the isolation of pure compounds from distillable mixtures. All too often in the college instructional laboratory the technique is neglected, or performed with a variety of primitive contraptions.[1]

The writer has fabricated apparatus of sufficiently simple construction that it can be assembled by a person of average ability in glass blowing—presumably the college instructor or one of his skilled students (See Figures 1 and 2).

The apparatus constructed was worked out with several essential considerations in mind, namely (1) the apparatus should be *all glass* with standard taper (or spherical) joints, thus eliminating all possible contamination from rubber connections, (2) the apparatus should operate under *continuous* vacuum such that the distillation does not suffer from interruptions inherent in the usual fraction cutters and the Noonan apparatus (see footnote), (3) a short fractionating column should be incorporated, and (4) the column, condenser, and fraction distributor should be of one-piece construction to eliminate leaks as much as possible and to simplify setting up. The last consideration was based on the premise that vacuum distilling is essentially a more complicated operation than most elementary laboratory processes; hence distilling apparatus should be *permanently* mounted and be ready for immediate use when the occasion arises.

[1] A somewhat standard operation, which is still in vogue after some sixty years, employs a Claisen flask attached to a regular distilling flask as a receiver, the latter being chilled by a meandering stream of water and evacuated through the side arm which is connected first to a trap and then to a water pump. [Several standard texts describe the method, *e. g.*, the laboratory manuals of Adams and Johnson (Macmillan Co., **1949**), Boord, Brode, and Bossert (Wiley, **1949**), and Fieser (Heath Co., **1941**).] The grand sum of one contaminated fraction can be collected during a single performance—provided that one's neighbor does not cause the water pump to back up by conducting a suction filtration. More complex assemblies employ fraction cutters, the design of which has evolved into something of a fine art in research laboratories. An ingenious one is that of Noonan [*Ind. Eng. Chem. Anal. Ed.*, **10**, 34 (1938)] which combines all necessary functions through a single stopcock, which is however of intricate construction and beyond the reach of the average glass blower. Noonan's apparatus suffers from a basic weakness, namely that during the separation of a given fraction and evacuation of the next receiver, the distilling flask is temporarily disconnected from the pump; inevitably there is an increase in pressure in the system and interruption of the distilling process.

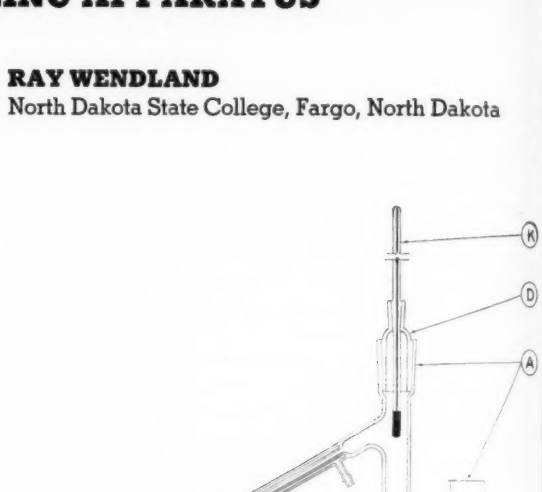

Figure 1. Construction Details for Vacuum Distilling Apparatus

The outcome of these studies is the apparatus pictured in Figure 1. Figure 2 shows a similar device intended as a fraction cutter for use on a fractionating column.

Items required for the construction of both pieces of apparatus are described below.

Item	*Description*[a]
A, B.....	29/42 standard taper joints
C.....	35/25 ball joint
D.....	Reducing adapter for thermometer 10/30 to 29/42
E.....	West type condenser (200 to 300 mm. long)
F.....	Claisen flask "T" connection taken from a standard 500-ml. Claisen flask
G.....	Distributor tube, 8 mm. O.D.
H.....	Connecting tubes (4), 11 mm. O.D. spaced 90 degrees around flask *I*
I.....	500-ml. flask with 35/25 ball joint
J.....	29/42 distilling flask
K.....	10/30 standard taper thermometer 0–250°C.
L.....	Connector tube for vacuum pump, 8 mm.
M.....	Large bore stopcock

[a] All parts are pyrex.

To the expert, construction of the apparatus wi

follow readily from the figures. However, the writer, after several bad experiences, considers it worth while to give a few detailed directions for the benefit of the amateur or occasional glass blower. Of all the connections shown, the one most troublesome is likely to be the rounded "T" joint *F* in Figure 1. After several attempts I gave up the idea of fabricating my own from large diameter tubing, and instead used a section of a 500-ml. Claisen flask as noted in the table. After taking off the side arm of the Claisen flask the upright tube was sealed to the thermometer joint *A*. The full length of this joint *A* is about 130 mm. below the ground surface; the combination of the two makes a fractionating column of convenient length. At the upper end of this column the condenser is sealed, as shown.

The use of the spherical (ball and socket) connection on the flask *I* is a novel feature. By its use the flask can easily be rotated to collect several different fractions and at the same time make perfect connection into the delivery tubes. These delivery tubes could at the same time be attached to standard taper joints with drip tips. This feature would be desirable, but of course adds to the cost and complexity of the system. It should be mentioned that a spherical flask such as *I* instead of the commonly used flat Erlenmeyer is an improvement in safety of operation, for the flat vessel will have much less structural resistance to collapse under atmospheric pressure than the sphere. Furthermore, the spherical joint and flask are commercially available as a single unit—an added advantage.

Further improvements of the apparatus can be envisioned. In a separate model, the writer provided a sealed and evacuated insulating jacket around the fractionating tube above *F* (Figure 1) which is then silvered for better heat control. The increase in glass fabrication difficulties is notable, and for some may not be considered worth the hazards involved.

USE OF A FRACTIONATING COLUMN

Since many types of fractionating columns have come into common use (*e. g.*, the Widmer spiral and the helix packed column) vacuum distillation through such columns requires a special take-off device or "fraction cutter." Again with the object in mind of designing an easily constructed device that permits *uninterrupted* distillation, the writer has built the apparatus shown in Figure 2.

The fraction arising from the column passes into the Claisen type side arm and comes into contact with the vertical condenser, from which the condensate passes through a dropper and falls into the stopcock tube. The collection and distribution of the fractions are made by exactly the same means as shown in Figure 1. The top of the condenser is sealed by means of 10-mm. tubing to the spherical male joint which supports the collection flask, this tubing at the same time being opened through a "T" for connection to a manometer and then to the vacuum pump. Thus the pump pulls simultaneously at the top of the condenser and through the receiver to provide uniform pressure distribution.

The apparatus described has been in service in this laboratory for the past year, both for student instruction in vacuum distilling technique—for which it was specifically designed—and for research purposes, for which it is entirely adequate. As an operational feature it cannot be argued too strongly that good distilling of this type requires a motor-driven vacuum pump, unless an unusually high-capacity aspirating system is available. All too often the ordinary desk aspirator fails at the critical moment. When one uses a standard motor-driven pump the usual precautions for protecting the pump from water and corrosive vapors should of course be duly observed.

The advantage gained in providing students with first-rate distilling equipment was considered worth the time required, and the results are recommended for other instructors. It may be added finally that single installations of such equipment when kept in constant use will accommodate the needs of a large number of students in rapid sequence, who would otherwise be spending a great deal of time setting up the cumbersome and crude devices mentioned earlier.

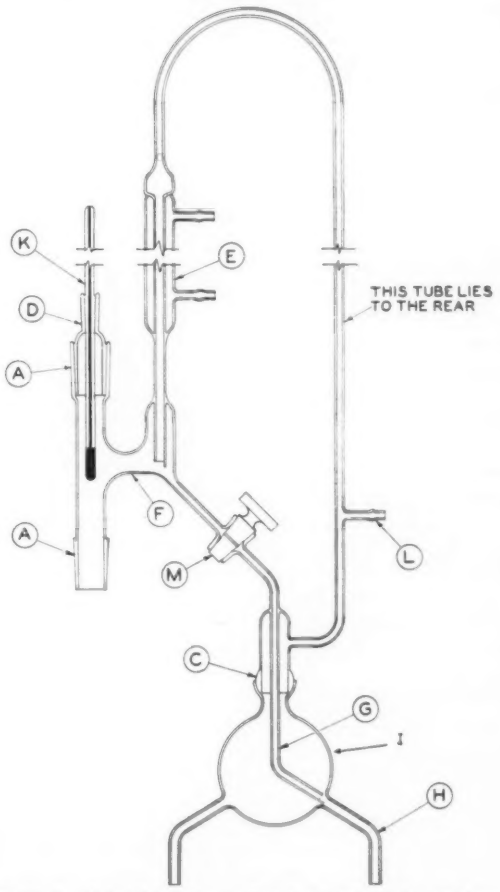

Figure 2. Takeoff for Vacuum Distillation Through a Column

Proceedings of the

PACIFIC SOUTHWEST ASSOCIATION OF CHEMISTRY TEACHERS

What the Chemist Should Bring to His Profession[1]

• THE IMPORTANCE OF A LIBERAL OUTLOOK

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In considering what the chemist should bring to his profession we should concern ourselves with those characteristics which are to be developed and improved in the individual, rather than fundamental aptitudes. We may take for granted that inherent talent for physical science exists in the individual together with the evidences of such talent, such as avid interest, willingness to work, and scholastic success in key subjects. There is no subsitute for natural aptitude, but there is considerable choice in how that aptitude is exercised and developed.

Perhaps there is no profession, aside from homemaking, that entails as varied a set of operations as that of the chemist. The home-maker is successful to the degree that she can work with her hands at a multitude of things, analyze problems of all magnitudes, be at once a gracious hostess and servant, and be at home in a hovel or a castle. The chemist may not have even a choice of materials with which to work but must be adaptable to any circumstance, as was one of our students who majored in foods and biochemistry and was employed in a cement plant. He may work in laboratory or plant, in an office or library, in a white collar or overalls, alone or closely associated in a team; and the members of the team may be chemists, engineers, laborers, clerks, bosses, or helpers. What manner of person, what kind of training and experience is the most suitable to unforeseeable requirements? Not a single kind of person nor a single kind of training will do, except as we can designate those features of personality and education which are common backgrounds for all activities.

I recall a few weeks ago asking a student to present himself for an interview with a potential employer. His response was, "I shall have to return home to change my clothes if I go today." He was attired as is the normal California sophomore. On another occasion I visited an industrial plant and met a former student, now in his thirties, in overalls. He excused himself saying I had caught him setting up a pilot plant he had designed. What implications are there here that a man wants to be presentable? To me it suggests that these men have a sense of the fitness of things and do not want to be misjudged. They will conform as the job requires, or convention dictates, and they want it understood that it is never too much trouble to dress, either for dinner or a dirty job. The problem of conforming is often not one of willingness so much as awareness. What is proper under given circumstances and how can one know? Good taste in dress, in manners, in speech, in deportment may seem incidental to being an artisan, but the qualities of good taste and a sense of fitness mark one as sensitive to what is good and bad, whether it be in technical work or normal living. One has a chance to develop and display his attributes of mind at home, in recreation, in social gatherings in as great a degree as in his professional work. One could urge that the chemist as a person should bring to his profession as broad a social experience as possible, to the end that he will understand those with whom he is thrown in contact and not be misunderstood himself.

Often I hear from personnel men: "We are all congenial here, do a lot of mutual entertaining in our homes. We want a man who will fit in." One company I know puts a premium on so-called cultural interest among its technical staff. Why are these things important? Because in work at the professional level one is not measured by the number of cords of wood cut per day, but by the quality and soundness of work and ideas. It is easier to convey ideas clearly to a man you know than to a stranger; one gets to know a man only through diverse contacts, not through the limited communion available from technical subject matter and technical language. One could urge development of *bona fide* interest in the humanities. Fortunately this does not detract from an adequate professional training, as it need not depend on formal educational facilities nor involve expenditure of money. It does have to be worked at, and it must be fun.

If I seem to underemphasize professional training it is

[1] A symposium presented at the University of California, Berkeley, on Feb. 12, 1951.

through the hope that others have been explicit in suggesting specific fields of work. I was once impressed by an industrialist who came our way looking for men. I asked: "For what kind of work are they needed?" He answered: "I do not know for sure, but we are shorthanded. Last year I went east for men with specific training, but this year our problems are as yet indefinite and we have found your graduates more generally adaptable." So this is the scope of our task; to be professionally educated one must be prepared to do anything, at least be prepared to learn anything. Perhaps an educated person is merely one with a high capacity to learn; if, in addition, he has sure reliance in his techniques and good judgment, he will go far. And how does one achieve a decisive judgment? By practice. A man who has never learned a complicated set of facts with certainty does not know what it means to know; if he has never performed a task with speed and precision he does not have the feel for work done adequately; if he is right only now and then, never sure of himself, his judgment is not trustworthy. So one may urge a high standard of achievement through elementary school, high school, and college, not for itself alone but for the basic training it implies. Not excellence and sureness uniformly at all points, but an experience with perfection which permits a man to say, "I know" and be right, is the goal. And if he can adopt this attitude toward his professional work and be inept in speech, careless in appearance, and unaware of the cultural values of his civilization, he runs the risk that the quality of his professional work may be misappraised and his judgment questioned.

• WORKING FOR THE GOVERNMENT

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THE answer to the question, "What should a chemist bring to his profession?" depends upon the type of work he is expected to perform. For example, one would certainly not look for the same characteristics in a candidate for a routine position as compared to one in which the candidate is to work as an assistant on a research project. Since my own experience has been concerned with research investigations in specialized fields of physics and physical chemistry, my remarks will be confined to the characteristics which I consider a chemist should possess if he is interested in working as a part of a research team.

As my phase of the discussion is concerned only with candidates seeking employment in Government research laboratories, it is appropriate to mention that, to a large extent, the choice of candidates is made for us by the U. S. Civil Service Commission. This commission periodically gives examinations for the various professional grades. To be a candidate for a position in a Government laboratory one has to pass such an examination successfully. In general, a position must be filled by one of the three top candidates on the eligibility list. On this account, our choice of candidates for any given position is limited.

Fortunately, there is a high degree of correlation between scholastic ability and other desirable characteristics; consequently in normal times it can be anticipated with considerable assurance that those who make good grades in the Civil Service examination will also be well qualified in other respects.

There are so many characteristics which are important that it is impossible to mention them all. The qualities of honesty, integrity, and loyalty, for example, are necessary characteristics for a chemist. These qualities, and similar ones, I will take for granted, and concern myself only with those which I think a research chemist should have, perhaps to a higher degree than required in many other fields of endeavor, if he is to be a success in his chosen profession.

There are four that I consider most important. They are intellectual curiosity, initiative, the ability to cooperate with others, and enthusiasm for his work. In addition, it is preferable that he have good basic training in chemistry and also in physics and mathematics.

All research chemists should possess these qualifications, at least in some degree, regardless of whether they work in an academic institution, for industry, or for the Government.

Any chemist who has developed these characteristics cannot help but be a success. New problems presented to him, as they surely will be in any live research organization, will be a challenge to him, and, because he is curious and likes to work at his profession, he will soon make important contributions to the progress of the research project.

Of the qualifications mentioned above, the ability to get along with people should not be underestimated. Research projects in Government laboratories are, almost without exception, attacked by research teams. This is necessary because of the difficult nature of the problems under investigation and the complexity of apparatus now used in a modern research laboratory. It is therefore essential that a chemist working in a Government laboratory be a person who can work well with others. It takes only one disgruntled member to block the output of the whole group.

Although good basic training in chemistry is valuable, I think that in the long run, it is more important

to possess the desire to learn, coupled with some initiative and the capacity for doing work. We have several examples at the Western Regional Research Laboratory of people who started in Government service as subprofessionals, but who now hold important positions on our research staff. These men succeeded in spite of the fact that they originally lacked good basic training, mainly because they possess the qualifications under discussion.

Any young chemist who has developed these same characteristics and has only an average scholastic record is, in my opinion, a more promising candidate than one who does not possess these qualifications regardless of how well he did in his classroom work. In general, of course, it turns out as one would expect; those with good scholastic records usually possess the other qualifications in the highest degree.

In conclusion it can be stated that a chemist who enjoys using his intellect, applies himself, and cooperates with both his supervisors and co-workers, will not only be successful, but, in addition, will be an asset to his profession.

WHAT INDUSTRY EXPECTS OF CHEMISTS

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IT TAKES all kinds of people to make a world and it takes all kinds of chemists to make the industrial world, but whatever kind of chemist you are or expect to be, industry expects you to do a first-class, top-notch job of it.

Industry takes for granted, once you have entered its ranks, that you come well-grounded in science, and although it would be possible to use this time for discussion of college curricula, I prefer to discuss what is expected of chemists other than a good knowledge of science, which we will presume they have already learned upon entering our profession. What industry expects beyond this scientific knowledge is that you will fit in and be a valuable member of the team; that you will develop and utilize your natural abilities and strive to overcome your deficiencies; that you will think constantly; that you will think straight and think in advance; that you will express yourself clearly, pointedly, and objectively; that you will show initiative and follow through; and that you will be loyal to your company and your associates. In short, industry expects you to bring to the organization the lift that comes from a high standard of character and performance realized from day to day.

Let us take these points in turn.

To fit in you should be adaptable, considerate of your associates, reasonable, and fair. These qualities should be used to make you popular in the high sense, the sense of reciprocal give and take that makes the industrial world tick. Strive at all times to be admired by your associates for more than your brilliance or knowledge of chemistry alone. These personal attributes are equally as important as the adequacy of your scientific training.

As individuals, we must work with our natural endowments, but we can build upon our strong points, our special abilities, and take stock of our shortcomings to overcome them as far as possible. You are expected to take a fair assessment of your own abilities constantly and to recognize your deficiencies as well as accept the assistance of others to improve yourself. Above all, recognize what you are best suited to do and make every effort to use this in its most constructive form in improving your productivity for the company.

Straight thinking is the key to sound action. Industry desperately needs thinking men. As a chemical engineer, perhaps I may be permitted to use someone's bitter definition of an engineer as "a man with a slide rule and a formula to substitute into." That remark is a warning that we must be mentally alert. New situations constantly arise and must be met by straight basic thinking which goes beyond a mere application of known scientific knowledge. The formula of the past probably will not work.

Thinking in advance is especially important. It is essential to the proper presentation of ideas. Much has been said of the art of writing reports; arrangement of subject matter, form of tables, etc. In our organization we are not greatly concerned whether a man has been exposed to this specialized training; we can teach him our own practice after he comes to us. We are, however, greatly concerned that a man develop the clear, straight thinking necessary to any presentation either oral or written. To do this it is most important that he be able to express himself well in speaking in order to convey his ideas well. He should be able to present a problem and develop new material logically and pointedly, with proper consideration of all the aspects and possibilities, and to arrive objectively at his conclusions.

The practice of continued thinking is a means of exploiting your scientific knowledge. The man who has a lot of encyclopedic scientific knowledge but does not use it is valueless. The use of the mind as a Fort Knox for knowledge is not half so important as accumulating a small fund of knowledge and investing it to advantage day by day. The returns are far greater. You can become a good carpenter with simple tools, and although they seem to you not very high-powered, they will serve

you well. You should use them often and they will be sharpened rather than dulled by constant use.

Perhaps the most difficult of all characteristics to identify in a member entering our profession, prior to actual trial, is his capacity for work, and it is probably one of the most overlooked requirements in training for your profession. Everyone should strive to achieve greater amounts of successful accomplishments by schooling himself in objective and clear thinking. It seems to me that decisiveness and confidence are two tools we must exploit the most to obtain maximum capacity for work.

Initiative is a quality often lacking and often confused with personal ambition. Initiative is associated with loyalty: it gives more than is asked, it unfolds the job, putting something new and valuable into it. By using initative you associate yourself with the progress of your company and industry, and thus move ahead yourself. Do not ever expect to boost yourself or your profession by fulfilling prescribed duties only. One other quality is especially worth mentioning: following through, or seeing to it that every job begun is brought to a prompt, successful conclusion. No ball games are won by players left on third base, and no industrial plays amount to much if the answers are not accurate, complete, and available when needed. Conscientiousness is thus another expression of loyalty and carries the same reward; you are identified with successful work in the minds of all concerned. And most important, loyalty can be thought of as respect, esteem, and even affection, for the company that employs you; it is a family relationship that identifies you with the organization as a responsible member. In this identification you think, "we," not "they" or "it"; and if for some reason you cannot have this feeling, it is unlikely that you can fulfill what your company expects of you.

• IT'S YOUR DIVISION

DIVISION OF CHEMICAL EDUCATION
of the American Chemical Society

THE Boston Meeting of the Division of Chemical Education consisted of the fewest number of papers in the recent history of the Division. Only six papers were given and many members of the Division were disappointed by the lack of a fuller program. The reasons in this particular case are fairly obvious. Deadlines for the arrangement of the 75th Anniversary New York Meeting had been set so early that the program for this meeting actually had to be completed before the Boston Program was outlined. Seven symposia to fill the New York Program had to be arranged within a few months. The Boston Meeting, it was decided by your Executive Committee, would consist only of individual papers, partly because so many symposia were being arranged for New York and partly because no individual papers would be permitted in New York.

The minimal offering in Boston resulted also from the hope of many members that they would be able to participate in the New York meeting. Even though the program was necessarily already completed, suggestions were received for two additional symposia for New York and several individual papers. These suggestions came in after the deadline for the Boston Meeting and had to be postponed until the spring of 1952, over a year away.

In the light of this experience it would appear that further publicity concerning submitting papers and symposia suggestions for national meetings might be in order. Had the members known of the ruling against individual papers in New York it is almost certain that the spring program would have been fuller. If the symposia deadlines had been more widely known some of those papers suggested recently might well have been offered in Boston.

It will probably be 25 years before another meeting will be held which will disturb the normal course of events as did the New York gathering but it might well be profitable to explain here the general method by which programs are collected.

The submission of general papers is adequately described in the preliminary programs which appear in *Chemical and Engineering News* some five months before each scheduled meeting. The source and organization of symposia is not so clearly defined. Suggestions for symposia originate in two places—from the individual members and from the Executive Committee of the Division. In either case the Executive Committee then chooses some person who is well known for his work in the field to be covered and asks him to organize and conduct the symposium. In general, symposium papers are directly solicited by the organizer of the symposium but occasionally an open symposium will be held to which individuals may submit papers.

The next meetings of the Society for which papers and symposia will be solicited are scheduled for the spring of 1952. These meetings will be held in Milwaukee and Buffalo, probably near the beginning of April. If you are interested in preparing or hearing a symposium on any particular topic at either of these meetings, now is the time to let our Divisional Secretary —Paul H. Fall, Hiram College, Hiram, Ohio—know about it so that the matter may come up before the Executive Committee.

J. A. CAMPBELL, *Chairman*

Report of the

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

OFFICIAL BUSINESS

MEETINGS

The 259th Meeting of the New England Association of Chemistry Teachers was held at St. George's School, Newport, Rhode Island on February 10, 1951. Leslie B. Coombs, Chairman of the Southern Division, presided. Forty-nine members and guests signed the register. William P. Elliott, Head of the Science Department and Assistant Headmaster of St. George's School, welcomed the Association to the campus.

The first speaker of the day was Francis Tripp, Professor of Chemistry at the New Bedford Textile Institute, who spoke on "Textile microbiology." Mr. Tripp discussed a number of tests which are made to determine the effectiveness of fungicides which are used in the treatment of textiles, and discussed in considerable detail the way in which these tests are carried out, as well as various fungicides which are used.

W. K. Lydic, Chief Chemist at the Owens-Corning Glass Works in Ashton, Rhode Island, discussed glass products in general and the uses which are made of textile fibers of glass. He brought with him a great many samples of products which are now on the market which utilize these glass fibers in new and interesting ways. He also issued an invitation to interested groups to visit the Ashton plant in order to see some of the research work which is going on.

After a delicious luncheon, served in the refectory, the afternoon session opened with a business meeting with the President, Helen W. Crawley, presiding. For the Membership Committee, it was reported that the total membership as of this date was 502 as compared with a membership of 495 at a corresponding date in 1950. The following additions to the roster were announced:

Seward E. Beacom, Assistant Professor of Chemistry, Teachers College of Connecticut, New Britain, Connecticut.
Ralph E. Brierley, Teacher of Chemistry, Cranston Senior High School, Cranston, Rhode Island.
Robert V. Dooley, Instructor of Chemistry and Mathematics, David Prouty High School, Spencer, Massachusetts.
Standish B. King, Assistant Dean, Western Massachusetts School of Pharmacy, Springfield, Massachusetts.
Dr. Vernon K. Kreible, Scoville Professor of Chemistry, Trinity College, Hartford, Connecticut.
Anna Mae Martin, Instructor in Chemistry, Regis College, Weston, Massachusetts.
James Mickles, Instructor in Chemistry, Massachusetts College, of Pharmacy, Boston 15, Massachusetts.
Bernham P. Miller, Head of Science Department, Norton High School, Norton, Massachusetts.
Thelma B. Roberts, Teacher of Chemistry, Biology, and General Science, Woodward School for Girls, Quincy, Massachusetts.
George W. Seabury, Master, Hyde Park High School, Boston, Massachusetts.
Ruperto Solimon, Chemistry Instructor, Lagaspi Junior Colleges, Lagaspi City, Philippines.
Frederic Lincoln Steele, Instructor in Science and Mathematics, St. Mary's in the Mountains, Littleton, New Hampshire.
Dr. Luke E. Steiner, Professor of Chemistry and Head of the Department of Chemistry, Oberlin College, Oberlin, Ohio.
Dr. J. Arndt Weicksel, Assistant Professor of Chemistry, Middlebury College, Middlebury, Vermont.
John H. Wolfenden, Professor of Chemistry, Dartmouth College, Hanover, New Hampshire.

The Treasurer of the Twelfth Summer Conference made his report, an abridgement of which follows.

Cash on hand 3/23/50		$ 646.14
Receipts:		
Registration fees and accommodations	$1635.90	
Advertisement on program	40.00	
Surplus	17.00	1692.90
Total receipts and cash		$2339.04
Expenses:		
Transferred to general treasury	$ 146.14	
Printing, programs, etc	310.14	
Meals and lodging	1055.07	
Social events	35.43	
Dues of new members, transferred to N.E.A.C.T. treasurer	84.00	
Key refunds, etc	109.50	
Miscellaneous office expenses	32.48	
Total expenses		1772.76
Balance 1/1/51		$ 566.28

The Executive Committee authorized the Curator to procure necessary equipment to file newspaper and other clippings dealing with NEACT affairs. The Committee has also reinstated the wartime category of *deferred membership* for those members who enter the armed services and other members who, in the opinion of the Executive Committee, belong in this category. Dues are remitted for deferred members who will receive notices and the *News Letter*, but not the JOURNAL OF CHEMICAL EDUCATION unless they elect to retain active status.

It was voted that the thanks of the Association be extended to Dr. Eccles and St. George's School for the delightful hospitality extended on this occasion.

Upon the completion of the meeting, members of the Association were conducted over the school, visiting the dormitories, laboratories, and famous chapel.

The 260th Meeting was held at the Pomfret School, Pomfret, Connecticut, on March 24, 1951. Carl P. Swinnerton, Chairman of the Western Division, presided and presented Dexter K. Strong, Headmaster of the Pomfret School, who greeted those present.

The first paper of the morning by Oliver L. Baril of the College of the Holy Cross dealt with "Vocational aspects of clinical techniques." Professor Baril emphasized especially openings in related fields for chemists with a biological slant, and indicated that there are many opportunities for students with special training to obtain positions as medical technicians, office assistants to doctors, pharmacists, etc.

Verne Williams of the University of Connecticut spoke on "The defense against atomic weapons." Professor William Orr, who was originally scheduled to give this address, was ill and Professor Williams, who is particularly interested in civilian defense, presented a very clear picture of the various effects of atomic bombs, the types of bursts, the dangers from each type, and possible protective measures.

After a luncheon at the Ben Grosvenor Inn, the business meeting was opened by the President, Helen W. Crawley. For the Membership Committee, the Secretary presented the following new members:

Dr. Saul G. Cohen, Associate Professor of Chemistry, Brandeis University, Waltham, Massachusetts.
Paul N. Dargie, Chemistry Teacher, Pawtucket Vocational High School, Pawtucket, Rhode Island.
Edward J. Desmarais, Chemistry Teacher, Rockport High School, Rockport, Massachusetts.
Dr. Adolphe Furth, Chairman of the Department of Chemistry, Assumption College, Worcester, Massachusetts.
Dr. Thomas O. Jones, Associate Professor of Chemistry, Haverford College, Haverford, Pennsylvania.
Paul M. Moulton, Teaching Fellow, Tufts College, Medford, Massachusetts.
Sister Mary of St. Jeanne of the A, Chemistry Teacher, St. Anthony's High School, New Bedford, Massachusetts.
Sister Mary Thomas, Chemistry Instructor, Matignon High School, Cambridge, Massachusetts.

W. George Parks of the Chemistry Department, University of Rhode Island, spoke briefly to the meeting, extending again a very cordial invitation to all persons to attend the Summer Conference. He announced that in so far as possible, people doing demonstrations would be supplied equipment and any materials needed. The University this year is once again holding its chemistry contest to stimulate interest in chemistry in the State of Rhode Island.

Upon motion it was voted that the Secretary be instructed to extend to Mr. Strong and to his Board of Trustees the gratitude of this Association for the very generous hospitality shown us.

The first speaker of the afternoon session was Raymond H. Wallace of the University of Connecticut. His lecture on the production of variations in plants and animals by ultrasonic vibrations was illustrated with colored slides, and also by living plant material which Professor Wallace brought with him.

In the second paper of the afternoon, Professor Ralph Bushnell of the University of Connecticut discussed various physical and chemical means which have been used to alter the genes of Drosophila. This lecture, too, was illustrated by slides, which showed very clearly the changes which take place in the chromosomes.

SUMMER CONFERENCE

THE New England Association of Chemistry Teachers announces that the Thirteenth Annual Summer Conference will be held during the week of August 19th on the campus of the University of Rhode Island. A symposium on the teaching of chemistry, with emphasis on science in general education, a workshop on pupil-participation in chemical demonstrations as classroom projects, and a demonstration of equipment used in research on radioactive materials have been scheduled. At the time of going to press, papers by prominent chemists had also been arranged for as follows: "Consulting chemistry as an example of industrial research," by Cornelia T. Snell, Foster D. Snell, Inc., New York; "Some biochemical aspects of the cancer problem," by George W. Kidder, Amherst College; "The chemistry of pyrazolones," by Paul E. Gagnon, Laval University, Quebec City, Canada; "What the Portland Cement Association is and what it does"; "Industry and the promising young chemist," by S. E. Q. Ashley, General Electric Company, Pittsfield, Massachusetts. Other topics include the medical aspects of nuclear radiation. As usual, the NEACT will be guests of one of the pleasantly located rural universities of New England where adequate scientific facilities and recreational advantages abound. The location of the University of Rhode Island, near the seashore in South County, is very well suited for the conference. There is a lake for swimming on the campus, several good golf courses nearby, surf bathing at Narragansett Pier and at the state beach seven miles away. Tennis courts will be made available. The meetings will be held in the new chemistry building and the conferees will be housed in dormitories across the street, where cafeteria meals will be provided. The fees for members will be as follows: registration fee, prior to August 1, $3.50; after August 1, $4.50. Dormitory fees will be $1.50 per person per night. Non-members will pay an additional fee which includes membership in the NEACT and a subscription to the JOURNAL OF CHEMICAL EDUCATION, which goes with membership (with suitable adjustments made to present subscribers). In addition, an active social committee has arranged a Rhode Island clam bake, a summer theater party, and social evenings. For wives and families, who will be most welcome, there will be arranged trips to historical sites and antique shops. (Such non-professional guests are accepted at a substantially lower registration fee.) For further information, write to the Conference Secretary, Miss Elizabeth Sawyer, Connecticut College, New London, Connecticut.

To the Editor:

This letter is intended as a commentary on the article entitled "An historical approach to the teaching of science" by Leonard K. Nash, in the March, 1951, issue of the JOURNAL OF CHEMICAL EDUCATION.

(1) The reference to Velikovsky is unduly vicious, and ill-fitting both the author of the paper and the ambition of it. It seems to me that this stunted comment is altogether incompatible with the intent of the essay and ridiculously dipole to what they are trying to teach at Harvard. I might ask Mr. Nash whether he has read Velikovsky *himself!*

(2) Concerning the hope for the successful teaching of science to nonmajor students by this historical approach: I have commented on this elsewhere (see my review in *School Science and Mathematics*, February, 1951). I do not believe that nonscience majors can get much out of this. A proper understanding of the science involved demands much more than the student can bring to it. An appreciation of the entanglement of fact and fancy is even further impossible for a student who knows no basic science. An inquiry of this sort would do beautifully in a senior seminar *for science majors* to which is brought an exacting knowledge of "scientific facts." And indeed it is the science majors who need just this humanistic approach!

JULIUS SUMNER MILLER

DILLARD UNIVERSITY
NEW ORLEANS, LOUISIANA

Recent Books

● APPLIED NUCLEAR PHYSICS

Ernest C. Pollard, Professor of Physics, Yale University, and ***William L. Davidson,*** Director of Physical Research, The B. F. Goodrich Co. Second edition. John Wiley and Sons, Inc., New York, 1951. ix + 352 pp. 93 figs. 15 × 24 cm. $5.

THE first edition of this work was a welcome primer for many nonphysicists who were attracted to nuclear science a few years ago. The enthusiasm and eloquence of the authors made the reading of this book both pleasant and instructive. This second edition represents an effort to take account of the tremendous progress of the intervening years and yet to remain "of service to the growing army of scientists and engineers, who, though not necessarily versed in the language of physics are using the products of nuclear physics. . . ."

The total amount of text in the new edition is approximately 50 per cent greater, but with the exception of Chapters I (Introductory) and VIII (Artificial Radioactivity in Practice), which are revisions of the same subject matter, the material of the first edition is mostly retained intact. A new chapter on nuclear chain reactions is added and considerable additions are made to Chapters IV (Accelerating Atomic Particles), V (Transmutation), X (Nuclear Fission), and in Chapter XII on cosmic rays. Five new appendixes are added on atomic masses, elementary pile theory, neutron diffraction, cross-sections, and experiments.

The large retention of material and method of presentation from the first edition obviously preserves most of the virtues of that work. The new material is of course largely devoted to developments of recent years and appears to give a balanced picture of nuclear physics today, although this is done at a somewhat higher level than the treatments carried over from the first edition. Perhaps this is intended to further the second objective of the authors "to make this a useful textbook in nuclear physics." It would indeed be surprising to find a book which could serve both purposes, and certainly the first edition found its main use in service to nonphysicists.

In retaining substantially unchanged a large fraction of the first edition, the authors have unfortunately kept most of the vices as well as the virtues of that work. Such substantial shortcomings as the erroneous description of Geiger action, the improper distinction between chemical and nuclear reactions, the apparently facetious suggestion that one test the silver in one's pocket after standing near an operating cyclotron, the confused discussion of nuclear isomerism and internal conversion, and the unsatisfactory discussion of absorption of radiations all remain practically intact from the first edition. Perhaps such aberrations should be overlooked in view of the obvious general appeal of a book written in so engaging a fashion.

RUSSELL R. WILLIAMS, JR.

UNIVERSITY OF NOTRE DAME
NOTRE DAME, INDIANA

● THEORY OF ELEMENTARY CHEMICAL ANALYSIS

Thomas H. Whitehead, Professor of Chemistry, The University of Georgia. Ginn and Co., Boston, 1950. vi + 233 pp. 11 figs. 22 tables. 15.5 × 24 cm. $2.75.

"THIS book is written for the student in a first course in inorganic qualitative analysis," presumably one given as part of the work in first-year general chemistry. "Its primary purpose is to guide the student to an understanding of the theoretical principles upon which any scheme of inorganic analysis is based."

The material presented in realizing this purpose consists of a review of atomic and molecular structure, mathematical operations, properties of solutions, and ionization; calculational work on the usual aspects (including redox) of equilibrium theory; a brief survey of colloids; and an outline of the reactions of the common cations and anions. In this latter section a survey of the reactions and procedures is given, with reasons for many of the operations and precautions in the scheme of analysis, but the information is not intended to be sufficiently complete to serve as laboratory working directions. The book "emphasizes the growing interest in semimicro methods, complex inorganic compounds, and the use of organic reagents in inorganic analysis."

The aims of the text are realized quite satisfactorily. The coverage is adequate, the discussions on the whole are sufficiently

complete, and are lucid enough to be meaningful even to the first-year student.

There are, however, places where inaccuracies have crept in, presumably in the interest of simplicity. The author of an elementary text of any sort steers a narrow channel between unjustifiable inaccuracy and unintelligible complexity; it is almost inevitable that he will be accused of the former by reviewers and of the latter by students. Nevertheless, this reviewer feels that such statements as (page 21) "polar compounds and electrovalent compounds are the same" and (page 22) "such compounds are called *nonpolar* compounds or *covalent* compounds" are harmfully misleading and could have been made more accurate without becoming incomprehensible to beginners. Similar are the statements (page 63) that the specific conductance "represents the conductance of 1 cubic centimeter of solution" and (page 90) that "the pH system . . . does not measure solutions which are more concentrated than 1 *M*. Thus a 4 *M* solution of HCl cannot have a pH value." Exception can also be taken, even at the elementary level, to some of the solubility rules (page 99): "All metallic hydroxides (and sulfides) are very insoluble in water except those of sodium and potassium. All ammonium compounds are soluble in water except $(NH_4)_2PtCl_6$ and $(NH_4)_2NaCo(NO_2)_6$." Relatively slight revision of some of these statements would eliminate most of the objections and increase the acceptability of the book to many potential users.

A valuable feature of the book is the inclusion of numerous solved examples of the various types of calculations. Additional problems and questions are given at the end of each section. Tables of logarithms and antilogarithms are included.

In appearance, typography, and binding the volume maintains the high standard we have come to expect of its publisher.

T. H. DUNKELBERGER

DUQUESNE UNIVERSITY
PITTSBURGH, PENNSYLVANIA

● ELEMENTS OF OPTICAL MINERALOGY. PART II: DESCRIPTIONS OF MINERALS

Alexander N. Winchell, **Emeritus Professor of Mineralogy and Petrology, University of Wisconsin, and** ***Horace Winchell,*** **Assistant Professor of Mineralogy, Yale University. Fourth edition. John Wiley and Sons, Inc., New York, 1951. xvi + 551 pp. 427 figs. 15 × 23.5 cm. $12.50.**

THE fourth edition of this compilation of optical data on minerals is most welcome to the many who have been using the third edition, now 18 years old. A. N. Winchell has had the aid of his son, Horace Winchell, in making this fourth edition.

Chief among the advances in mineralogy over the past two decades have been the further elucidation by use of X-rays of the crystal structure of minerals, the development of a more logical classification of minerals, and the further determination of isomorphous relations in many of the mineral groups. These have been incorporated in the new edition.

Optical properties are among the most useful of characteristics for the identification of nonopaque minerals and solids generally. A few minerals, such as quartz (SiO_2), have simple and fixed chemical compositions. Much more commonly, however, minerals have complete or limited isomorphism or chemical substitution, and many mineral groups show chemical variations in several directions between the various end members. The Winchells have long urged this view of minerals and they emphasize it in this book. Where the isomorphous variations are not too complex it is possible to relate optical properties to chemical composition as determined from analyzed specimens and to draw curves depicting the relationships. These commonly make it possible to learn as much from a few optical determinations, such as index or indices of refraction, birefringence, and optic sign as would be learned from a rather laborious chemical analysis. These methods are equally applicable to solids formed in the chemical laboratory. The authors have shown considerable ingenuity in constructing diagrams to show variations between end members of complex isomorphous groups and have written an introductory chapter describing the types of diagrams used. Some of the diagrams seem too complex to be helpful, however.

Other data supplied for the minerals in this compilation include crystal relations, space group, unit cell, specific gravity, hardness, chief chemical tests, indices of refraction, optic sign, optic angle, birefringence, pleochroism, dispersion, optic orientation, alterations, geologic occurrence, and diagnostic characters.

The publishers have done an excellent job of printing. Considering the vast amount of data presented and the many technical symbols used, the book seems remarkably free of typographical errors. Most of us dislike to pay $12.50 for one volume of a three-volume set, but the price is probably not excessive for a book of this size and kind.

The other two volumes of this set are Part I: "Principles and Methods," fifth edition, and Part III: "Determinative Tables," second edition.

ALONZO W. QUINN

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PROVIDENCE, RHODE ISLAND

● ORGANOPHOSPHORUS COMPOUNDS

Gennady M. Kosolapoff, **Associate Professor of Chemistry, Alabama Polytechnic Institute. John Wiley and Sons, Inc., New York, 1950. vii + 376 pp. 15 × 23.5 cm. $7.50.**

THIS text is the first in English which attempts a comprehensive review of the chemistry of organic phosphorus compounds. In view of the increasing importance of this field the author has made a timely and important contribution to the literature of organic chemistry. All information on known phosphorus compounds available up to January, 1949, is incorporated in the body of the text and the literature from this date to January, 1950, is in an appendix at the end of the book.

This book is designed for the organic chemist, and despite the current biochemical interest in organophosphorus compounds those substances of biological importance whose structures are not firmly established have not been included. It is difficult to reconcile Professor Kosolapoff's recognition of the significant role of these substances in biological phenomena with his statement that "an attempted summary of them at this time would become obsolete even during the course of its preparation."

The classification of organophosphorus compounds employed in this book is shown by the chapter titles: Phosphines and Related Compounds; Halophosphines; Halophosphine Halides and Phosphonyl Halides; Quaternary Phosphonium Compounds; Tertiary Phosphine Oxides, Sulfides, and Selenides; Phosphinous, Phosphonous, and Phosphonic Acids, their Sulfur Analogs and Esters; Phosphites and Thiophosphites; Phosphates, Halophosphates and Thio Analogs; Compounds with Phosphorus to Nitrogen Bonds; Quasi-phosphonium Compounds; Derivatives of Anhydro Acids.

The material in each chapter has been arranged systematically according to a general plan in order to facilitate locating information. The initial statement is a definition of the class of compounds considered in the chapter. This is followed by a detailed discussion of the synthetic methods used for this class of compounds. Each distinctly different preparative reaction is designated by a Roman numeral which is also used in the tabulation of compounds to indicate the mode of preparation of the compounds listed. The next section is termed General Characteristics and it is a summary of the general chemical and physical properties of this class of compounds; exceptions to the general pattern of chemical behavior are noted.

One of the most valuable features of this book is the compilation in each chapter of all known compounds of this class. These are listed together with important physical properties such as melting point, boiling point, and densities. References to the literature are cited for each compound as well as their convenient

solid derivatives and their melting points. In view of the confusion in nomenclature of organophosphorus compounds the author has wisely adopted the device of tabulating these substances by their condensed structural formulas. These are set in bold type so that they are easily read. The compounds in each chapter are also arranged by classes, *e. g.*, primary (RPH_2) secondary (R_2PH), and tertiary (R_3P) phosphines, biphosphines ($R_2P—PH_2$), and phosphine-methylenes ($R_3P{=}CR_2$). The last section of each chapter consists of a numbered list of literature references which are arranged alphabetically by the authors' names.

Professor Kosolapoff's style is both lucid and stimulating and he has been scrupulously careful in assembling the contents of this text. In the absence of any general theory of reaction mechanism for the phosphorus compounds the author has not included this aspect of the topic. The reviewer is of the opinion that the discussion of such material would make this excellent text more stimulating.

The paucity of information on organophosphorus compounds in most organic textbooks and the merit of this book make it an important and necessary addition to every chemical library.

JACOB G. SHAREFKIN

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Brooklyn 10, New York

● TEXTBOOK OF ORGANIC CHEMISTRY

***Louis F. Fieser* and *Mary Fieser*.** **D. C. Heath and Co., Boston, 1950. viii + 741 pp. 16 × 24 cm. $6.**

The new edition of this well-established text has brought it up to date on recent developments (lithium aluminum hydride reductions, orlon, cortisone, etc.). Two new features, a summary at the end of each chapter and answers to all problems (incorporated at the end of the book), should increase its usefulness. The outstanding qualities of exactness in treatment of detail coupled with a truly interesting presentation have been retained. Errors of fact are few in number; on page 83, however, the statement that the alkylation of sodium acetylides is confined to methylation should be modified to include higher *primary* alkyl halides.

One other new feature, the inclusion of material on reaction mechanisms, has been used with restraint and, for the most part, in places where a more detailed picture will aid in understanding. In a few instances this phase of the presentation has not been handled as well as might be desired. When the authors suggest that reactions in acidic solutions involve methoxide or hydroxide ions (pages 142, 145, 162) they are more likely to confuse the student than to give him a clearer picture of the reaction in question. On page 66 hypohalite additions to alkenes are discussed as if they occurred only in alkaline medium, and hydroxide ion is indicated to be a catalyst for the reaction between chlorine and water.

The text may be highly recommended on most counts.

F. G. BORDWELL

Northwestern University
Evanston, Illinois

● PHYSICAL CHEMISTRY, EXPERIMENTAL AND THEORETICAL

***G. Van Praagh*, Head of the Science Department of Christ's Hospital, Horsham, England. Cambridge University Press, New York, 1951. xiv + 295 pp. 113 figs. 5 plates. 15 × 22 cm. $2.75.**

As indicated in the preface, this book is presented "for a laboratory manual of experiments in physical chemistry suitable for school and college use." Because it is felt by the author that "the limited time and equipment usually available render impracticable many physical chemistry experiments described in existing text-books" a number of the more advanced and elaborate of these have been "simplified and adapted" and others omitted.

It is frequently the case that students do not "get a real understanding of a new subject until they observe the phenomena for themselves in the laboratory" and consequently "each topic is introduced by a few short experiments. . . ." These are followed by a brief and usually very clear discussion of the theory involved and of its historical development and, at the end of the chapter, other somewhat more difficult experiments.

"The classical atomic theory, on which the science of theoretical chemistry is largely based, is treated more fully than usual. In the author's opinion, the history of the atomic theory in the first half of the nineteenth century is rarely given the place of importance it merits, and. . .it is not surprising that students do not have a clear understanding of its significance." With this opinion the reviewer feels inclined to agree. More or less coincident with the widespread adoption of the concepts of atomic structure and electronic theories of valence as introductory material in the general chemistry textbook, the logic of the development of our fundamental chemical theory, upon which our whole system of atomic and molecular weights, formulas, equations and valences depends, has disappeared from our books and, it is feared, from our teaching. We might well ponder the effect of this revolution on future scientific thinking.

"More experiments are included than would normally be done. . .in an introductory course." The total is over two hundred. But many of these are short and involve only observation, not measurement, and are frequently used as laboratory or lecture demonstrations in the general chemistry course in American colleges. Many of the longer experiments, also, are descriptive in nature and apparently no attempt is made in any of the experiments to obtain results with high precision.

No problems or written exercises are included and no references except in a bibliography of about twenty books, all of English authorship.

The extensive collection of experiments as well as the clear theoretical explanations of the theory involved make this book worthy of examination by teachers of elementary courses in physical chemistry. Other teachers may find many suggestions of value also. Very few errors of any sort have been found.

W. B. MELDRUM

Haverford College
Haverford, Pennsylvania

● SOURCEBOOK ON ATOMIC ENERGY

***Samuel Glasstone*, Consultant to the United States Atomic Energy Commission. D. Van Nostrand Co., Inc., New York, 1950. v + 546 pp. 16 × 24 cm. $2.90.**

Originally planned to serve as a comprehensive "sourcebook" on atomic energy for the use of authors, textbook and science editors, Dr. Glasstone's latest volume will appeal to chemistry teachers as a readable and reliable reference book in the rapidly developing field of nuclear chemistry and physics. It was written under the auspices of the U. S. Atomic Energy Commission, and from the unusually low price for which it is offered it is assumed that part of the cost of producing the book was borne by this agency.

The first chapter gives a quick review of the atomic theory and the periodic table. Chapter II presents an elementary discussion of the developments of ideas about the constituent parts of atoms, going back to the early experiments on the passage of electricity through gases. It then proceeds to the discovery and characterization of electrons, protons, positrons, X-rays, particles from radioactive elements, and neutrons. Mesons, neutrinos, and other less familiar entities are not introduced until much later. The few chemistry teachers who find that the first 57 pages contain information with which they are unfamiliar should regard themselves as nineteenth century in outlook. Chemistry teachers who have rated themselves as twentieth century types by the above criterion will still need familiarity with the topics

covered in the remaining 489 pages if they wish to be considered to be up to date at mid-century. This "Glasstone Report" makes it possible to attain this objective with minimum effort. The treatment given to fundamental nuclear science is no more difficult than that usually presented to college freshmen, but the scope is broader. It proceeds from the introductory material with a survey of nuclear radiations, isotopes and their separations, nuclear transformation, particle accelerators, nuclear structures, nuclear forces, and nuclear fission. The book concludes with chapters on utilization of nuclear energies, including bombs; the new elements; uses of isotopes (as tracers); cosmic rays and mesons; and finally health physics.

At the Brookhaven conference on rare earth elements (Jan. 17–19, 1951) one of the physicists is quoted as having remarked, "It's about time that chemists were disabused of their oversimplified notions of valence. They've been lucky so far in getting by with it, but pretty soon they will have to face the complex facts of the real situation." The same is equally true of many chemists' ideas about nuclear science. This book will make it possible for them to bring themselves up to the starting line. They will then need to be disabused of their oversimplified concepts of nuclear phenomena. So many are so far behind, however, that Dr. Glasstone's book performs a genuine service.

The title may be somewhat misleading, since it contains no references to original literature and no quotations from original sources, and is therefore not a *source book* in the usual sense. It is, instead, a statement of what is generally accepted to be true, a sort of quintessence of knowledge (on an elementary level), in this new and, strangely enough, politically important field of nuclear science.

As already implied, the book was not written for the expert in nuclear physics, nor, on the other hand, for a person completely untrained in science. A college alumnus who had both freshman chemistry and physics ought to possess the background to tackle it, if he has a sufficiently strong reason for doing so. It is an ideal reference book for chemistry teachers, both high school and college, and for chemistry majors in colleges and graduate schools, and is highly recommended.

LAURENCE. S. FOSTER

16 West Street
Belmont, Massachusetts

• THE TECHNOLOGY AND CHEMISTRY OF ALKALOIDS

Frank E. Hamerslag, Consulting Chemist. D. Van Nostrand Co., Inc., New York, 1950. viii + 319 pp. 14.5 × 22.5 cm. $6.50.

As the title indicates, the subject matter concerns itself for the major part with the technology involved in the isolation of various alkaloids from natural sources on a commercial scale. The chemistry of the alkaloids covered is treated in a cursory manner which often leaves much to be desired as far as up-to-date coverage and accuracy are concerned. Following a chapter in which general commercial procedures for the extraction of alkaloids are presented, detailed discussions of the following groups of alkaloids are given: Aconitine, Arecoline, Coca Alkaloids, Colchicine, Curare Alkaloids, Ephedra Alkaloids, Ergot, Hydrastine and Berberine, Ipecacuanha Alkaloids, Lobelia Alkaloids, Nicotine, Alkaloids of Nux Vomica, Physostigmine, Pilocarpus Alkaloids, Sparteine, Solanaceous Alkaloids, Veratrine, and Yohimbine. It was a source of some consternation to this reviewer to find the statement in the preface that, "Since the book deals mainly with the commercially practical alkaloids, it was felt that the purpose of the book would not be materially affected if the morphine and cinchona alkaloids were omitted." Inasmuch as these two groups probably represent the most important groups of alkaloids, this omission appears to be utterly unwarranted and detracts vitally from the usefulness of the book.

Some attention has been given to the replacement of natural alkaloids by synthetic products, but again unfortunate omissions are apparent. Brief mention is made of the therapeutic applications of the alkaloids discussed, but no discussion of synthetic substitutes, *e. g.*, local anesthetics for cocaine or antihistamines for ephedrine, is given.

The typography is in general not good. This applies particularly to the confusion as to the presence or absence of double bonds in ring formulas. For example in Chapter VII all benzenoid double bonds are shown in the formulas, but in the succeeding chapter none are shown. This leads to the conclusion that the ephedra alkaloids are derivatives of cyclohexane rather than benzene unless the reader already happens to be familiar with these substances. Several omissions of bond lines in structural formulas, notably in alkaloids carrying methylenedioxy groups, are apparent. A fairly large number of typographical errors in the text were also noted.

Despite its shortcomings, the book serves a valuable purpose in assembling in one place the various procedures available for the isolation of the alkaloids treated. This will be of service both to the technologist and to the laboratory chemist interested in this phase of alkaloid chemistry.

ROBERT C. ELDERFIELD

Columbia University
New York, New York

• PHYSICO-CHEMICAL CONSTANTS OF PURE ORGANIC COMPOUNDS

J. Timmermans, Professor of Physical Chemistry, Universite Libre, Brussels, and Director of the International Bureau of Physico-Chemical Standards. Elsevier Publishing Co., Inc., New York, 1950. viii + 693 pp. 17 × 24.5 cm. $12.50.

According to the author, this volume presents the results of the fruits of a quarter of a century's activity of his laboratory at the University of Brussels on physico-chemical standards and combines these results with those provided by a review of similar data in the literature. There are presented tables of values of the simple physical properties as reported originally by one or more investigators whose work is deemed to merit consideration. For the various compounds covered, information and references are given concerning methods of preparation. The properties considered include critical constants, vapor pressure, freezing point, temperature of transition, density of the vapor, specific heat, heat of combustion, boiling point, refractive index, density, viscosity, surface tension, heat of fusion, heat of vaporization, dielectric constant, and critical solution temperature. Not all these properties are discussed for each compound, and for some of the properties discussed only references to the original data are given. For some of the properties values from the literature are reproduced. The selection of data consists simply in deciding which authors' values are to be reproduced, rather than an actual selection of "best" values. Appropriate references are given for the cited values.

The compounds covered in this volume include hydrocarbons (191 pages), halogenated derivatives (92 pages), oxygenated derivatives of the aliphatic series (155 pages), oxygenated derivatives of the aromatic series (32 pages), oxygenated derivatives of the polymethylenes (10 pages), heterocyclic oxygen compounds (5 pages), sugars (2 pages), mixed oxyhalogenated derivatives (11 pages), nitrogen derivatives of the aliphatic series (34 pages), nitrogen derivatives of the cyclic series (26 pages), oxynitrogen derivatives (25 pages), mixed halogenated nitrogen derivatives (8 pages), sulfur derivatives (15 pages), derivatives with other elements (3 pages). The list of references covers 27 pages and is preceded by a short historical introduction of 3 pages.

While the author has striven to make the book up to date as of January 1, 1950, it is apparent that a number of important publications appearing in the literature prior to this date have not been examined. Several of these are referred to in an addendum of one page with the statement "we have become acquainted with the following works too late to include them in the tables."

This reviewer feels that readers should utilize Professor Timmermans' compilation on hydrocarbons more as a reference work than as a selection of best data, because data on hydrocarbons are given in a more complete and up-to-date manner in the tables of "Selected Values of Properties of Hydrocarbons," which are issued currently by the American Petroleum Institute Research Project 44 at the Carnegie Institute of Technology, Pittsburgh, Pennsylvania. In this work this latter project has had the benefit of prompt first-hand contact with the new data obtained by the American Petroleum Institute Research Project 6 on hydrocarbons of high purity, as well as the many new data obtained by the American Petroleum Institute Research Projects 42, 45, and 48.

For the many nonhydrocarbon organic compounds covered, readers will find this volume extremely helpful as a guide to the better data reported in the literature. It is to be hoped that with this volume as a stepping stone, the data on the nonhydrocarbon organic compounds may some day approach in quality and quantity the corresponding data now available on hydrocarbons.

Professor Timmermans is to be complimented on this work, and science is indebted to him for bringing into one volume the results of his lifetime of work in this important field.

FREDERICK D. ROSSINI

CARNEGIE INSTITUTE OF TECHNOLOGY
PITTSBURGH, PENNSYLVANIA

● COLLOID SCIENCE

James W. McBain, **Director, National Chemical Laboratories, Poona, India. D. C. Heath and Co., Boston, 1950. 450 pp. 185 figs. 23 tables. 16 × 24 cm. $6.**

THIS well-known authority in the field of colloid science has prepared a book of 27 chapters which will be found most useful to physicists, chemists, and biologists who desire a well-rounded introduction to the subject of colloid science.

The author is congratulated upon the service which he has rendered and the publishers are complimented for the beautiful manufacturing job.

ARTHUR W. THOMAS

COLUMBIA UNIVERSITY
NEW YORK, NEW YORK

● BYPRODUCTS FROM MILK

Earle O. Whittier **and** ***Byron H. Webb,*** **Bureau of Dairy Industry, Agricultural Research Administration, U. S. Department of Agriculture. Reinhold Publishing Corp., New York, 1950. viii + 317 pp. 23 figs. 40 tables. 16 × 24 cm. $6.**

THE stated purpose of the book is to bring together in one volume the various methods of utilizing by-products previously available in Federal and State bulletins, patents, and technical journals. Promising procedures, not yet commercial, have been included. The book is directed to students of dairy science, research workers, supervisors in food manufacturing plants, and to operators of small dairy or other food manufacturing plants, as well as to plant managers and engineers.

The physical and chemical characteristics of milk, skim milk, whey, and buttermilk and their components are presented. Methods of converting these into foods as well as using in foods are given. Also, non-food products are included. Directions for manufacturing many of these are given with formulas and procedures. Different types of processing and equipment used are described along with analysis and testing.

Theoretical discussions are included only to the extent necessary for the understanding of the principles on which the manufacturing procedures are based. At the end of each chapter, there are references, not all-inclusive, but selected for furnishing the most practical and adequate information on the principles and procedures presented.

In addition to the direct by-products, information is presented on beverages from by-products, such as various types of buttermilk, condensation products from whey, condensed products, dried products, cheese and cheese products, various bakery products, various miscellaneous foods such as frozen desserts, confections, meat and egg substitutes, and others. Various canned products are discussed and methods of manufacture are given.

Each of the eleven chapters has been written by either one or the other of the two authors, except the one on bakery products, and here one of the authors has collaborated with L. V. Rogers as senior author.

EARL W. FLOSDORF

F. J. STOKES MACHINE COMPANY
PHILADELPHIA PENNSYLVANIA

● PHYSICAL ASPECTS OF ORGANIC CHEMISTRY

William A. Waters, **University Lecturer and Demonstrator in Organic Chemistry, Oxford University. Fourth edition. D. Van Nostrand Co., Inc., New York, 1950. xii + 539 pp. 26 figs. 42 tables. 14 × 22 cm. $8.**

UNLIKE a few "revised editions" being perpetrated upon the chemical buying public with no revision and little re-editing, the fourth edition (third for Van Nostrand) of Waters' popular text is in truth rewritten in large part. The organization of the book is essentially the same as the 1936 edition, having been changed by reversing the order of chapters in two cases, by new titles for some chapters, and by rearranging the order of presentation within several chapters.

The most thoroughly rewritten chapters in which the bulk of new topics appear are the two on free radicals (in which Waters' own work is substantial), substitution reactions of organic halogen compounds (revised in terms of current theory of the English school of organic chemists), ester hydrolysis and esterification (rewritten in modern language), and the study of molecular structure (almost entirely new since the first edition). References to the literature after 1940 are frequent in these chapters and scarce in the remainder of the book.

Many improvements in clarity or simplification have been made, for example, by critical selection of terminology: the self-descriptive words homolytic and heterolytic have replaced what were in the 1936 edition called (misleadingly, I thought) nonionic and ionic reactions, respectively; the words basylous and acylous, never popular in this country, have been dropped; and the word prototropy substituted for desmotropy.

Waters has not abandoned the idea of a localized pair of electrons in a chemical bond but he has in a qualitative way piled the concepts from resonance theory and wave mechanics on top of the older theory. The result is a conservative picture in non-mathematical terms presented in very clear exposition.

LEALLYN B. CLAPP

BROWN UNIVERSITY
PROVIDENCE, RHODE ISLAND

● THE BIOCHEMISTRY OF THE NUCLEIC ACIDS

J. N. Davidson, **Gardiner Professor of Physiological Chemistry, University of Glasgow. John Wiley and Sons, Inc., New York, 1950. ix + 163 pp. 15 figs. 4 plates. 11 × 17 cm. $1.75.**

IN VIEW of the interest that has developed during the last decade in nucleoproteins and their constituent nucleic acids, this well-written and readable summary of our knowledge of the chemistry and physiology of the nucleic acids is welcome.

The broad approach to the subject is indicated by the titles to the fifteen chapters of the book. There are chapters on the hydrolysis products of nucleic acids; the structure and properties of polynucleotides and nucleoproteins; nucleic acid content of tissue; nucleases and related enzymes; nucleic acids in cell

cytoplasm, the cell nucleus, bacteria and viruses; the metabolism, biological activity, and biosynthesis of nucleic acids. Considerable space is devoted to a description of procedures employed for the quantitative study of the chemistry of the nucleic acids and for studying their distribution in plant and animal tissues and cells. Methods of chromatography applied to nucleic acids, the use of ultraviolet absorption to detect nucleic acids in tissues, histochemical tests including enzymes and ultraviolet photomicrography are given in some detail.

The author has been very careful to define our exact knowledge of the chemical structure of the constituent compounds and the manner in which they are linked in nucleic acids. He warns of the danger of generalization as to the chemistry of this class of substances. To avoid this, he recommends, for example, that nucleic acids be designated as pentose nucleic acid or deoxypentose nucleic acid when the sugar has not been definitely identified.

In the nucleic acid field where so much work is being done, it is undoubtedly true, as the author indicates, that some of the material appearing in this book will be superseded by more recent discoveries. But in this reviewer's opinion, the present status of the subject is so well presented, supplemented with an excellent bibliography for each chapter, that the direction of current investigation is clearly indicated. This is true of the biosynthesis of nucleic acid constituents, a field in which lately significant contributions have been made.

F. A. CAJORI

University of Colorado School of Medicine
Denver, Colorado

● LABORATORY DESIGN

Edited by *H. S. Coleman,* Mellon Institute, Pittsburgh. Reinhold Publishing Corp., New York, 1951. ix + 393 pp. 305 figs. 23 × 31 cm. $12.

This splendid publication, prepared by direction of the National Research Council, unquestionably takes top place among works of its type, and will be a "must" for all architects and technical advisers contemplating new laboratories. Although the volume includes more or less engineering, physics, etc., it is after all primarily a guide to construction of chemical laboratories, both academic and industrial. Its beautiful rendition of excellent cuts on smooth, high-class white paper almost justifies the $12.

Edited by the principal technical adviser in construction of the magnificent Mellon Institute building, this book is a compilation of 42 articles by competent specialists. It might be described as the much-revised report of a 26-year symposium conducted by the persistent National Research Council. The editor is to be complimented on a concisely-written work, packed with valuable information.

Of the four main sections, Part I, 7 chapters, deals with "general" topics such as Furniture, Plumbing, etc. Part II, 10 chapters, discusses in succession academic laboratories by specific type—Analytical, Organic, etc. Part III, 12 chapters, gives similar individual treatment to industrial laboratory types, but with much useful application to university research plants. Part IV, 13 chapters, discusses individual American laboratories, including Mellon Institute, U. S. Regional, Bell Telephone, and Northwestern Technological Institute laboratories.

Part I is written by persons with industrial connections, and these authors occasionally show understandable reluctance to compare critically the competing devices available for a given purpose. For example, fire extinguishers are not adequately treated. In other words, the building committee cannot learn all that is right or wrong from the printed word.

If the reviewer must find something that should have been included in this volume, he would propose a chapter entitled How to Get Along with the Architect. We would like to be as optimistic as architect R. L. Wank (Chap. 1) but we fear he forgets that the good old board of trustees isn't likely to go to New York or Detroit and employ one of the relatively few architectural firms that really understand this business. The local architect gets the commission, and the professor in charge of the building committee settles down to a three-year job teaching him, the inspector, the contractor, and *himself,* what it's all about. The architect has his grievances also—witness the engineering-minded professor who draws up the whole chemistry building in full partition detail before he even meets the architect!

G. ROSS ROBERTSON

University of California
Los Angeles, California

● SCIENTIFIC RUSSIAN

James W. Perry, Associate Professor of Modern Languages, Massachusetts Institute of Technology. Interscience Publishers, Inc., New York, 1950. xxix + 816 pp. 16 × 23.5 cm. $7.50

This book is based on an idea that is wholeheartedly supported by the present reviewer. Scientists should be helped to follow the foreign-language scientific literature by the designing for them of special courses on an elementary level to save their time and effort. This is especially true in the case of Russian for English-speaking scientists, since Russian has less common vocabulary with English than do German or French. It is indeed desirable that a scientist, having satisfied his first need, should expand his knowledge of Russian into the language in general.

In order to learn to read the Russian scientific literature one should have a text stressing the study of those features that are characteristic for the language of science, as distinguished from the language of conversation and *belles-lettres.* In some cases these features are common to all languages; in other cases they are peculiar to Russian. In the vocabulary of the language, they comprise, in addition to the specific terminologies of the individual sciences, a large number of words of a high frequency in all sciences. A substantial portion of words in the latter category are cognate to English, German, or French; this category also includes many "difficult" words, but relatively few idiomatic expressions, as compared to the language as a whole. The grammatical features of the Russian language of science consist of a high frequency of the passive mood and of impersonal expressions, of infrequent use of the first person, etc.

Professor Perry obviously had in mind these characteristics of the Russian language of science in selecting, painstakingly arranging, and annotating his material. The result is a book that is particularly suitable for self study. It is a useful textbook for those classes of Russian (unfortunately, few in number as yet) which are composed of scientists exclusively, especially if its reading material is supplemented as necessary to suit the interests of the students. It is not well adapted for use in mixed classes where scientists study elementary Russian together with non-scientists, since the latter will have difficulty in understanding the scientific connotations of the sentences used to illustrate the grammar; however, in such classes the reading material can be used for out-of-class assignments for the scientist-students.

The material is graded with care and is arranged in forty lessons. Each contains grammatical discussions with numerous illustrations of the rules involved, a reading exercise, and a translation exercise from English into Russian. Beginning with the seventh lesson, the reading material constitutes descriptions or discussions of scientific subjects. The vocabularies at the end of the book are well organized and supplied with explanatory notes. The list of abbreviations will be appreciated by the student.

Although the language used by writers on different branches of science has much common vocabulary, it is regrettable that the reading material is largely in the fields of physics and chemistry. Very little is given on biology; the geological and mineralogical sciences are represented by only one article on crystallography; mathematics is not represented. Lists of Russian terms and important expressions peculiar to the various fields of science would have been helpful to the students of these respective fields.

The apparent emphasis of this book is on grammar. Having in mind a scientist who studies Russian on his own, the author gives the grammatical explanations in great detail and makes

numerous comparisons with the usage of the corresponding grammatical forms in the English language, probably to make up for the explanations that would be supplied by the teacher. This occasionally becomes cumbersome, as in the discussion of negative sentences in lesson 20, and still more in the discussion of the Russian alphabet with which a part of the introductory chapter and the first two lessons are concerned. Accordingly, the book is longer than it would have been if the author had had in mind primarily classroom use.

Desirable grammatical features of this book are: the early and repeated presentation of the effect of suffixes and prefixes in vocabulary building, although this is illustrated with verbs only; a good treatment of words cognate to English; and a justifiable stress on the significance of participles in the language of science. The declensions and conjugations, both regular and irregular, are outlined in a manner that will help the student to acquaint himself with these forms and to refer to them later.

On the other hand, one cannot agree with the extent of emphasis placed on some forms; *e. g.*, the passive mood and verbs that have the ending of reflexives (*sya*) but are not always actually reflexive. The comment on page 58 stating that verbs of non-Russian origin having a single infinitive may be regarded as incompletely assimilated into the Russian language leaves out of account the fact that there are purely Russian words which similarly can be used in both the imperfective and perfective aspects (for instance, *issledovat'*—to investigate).

The success of this book will be, above all, a function of the interest in the Russian scientific literature. Even those who believe that, for practical reasons, a textbook of Russian for scientists should be limited to graded reading material with suitable vocabulary-building exercises (with references to grammatical rules given in a separate text) will acknowledge that this book will materially help to satisfy this interest.

J. G. TOLPIN

UNIVERSITY OF CHICAGO
CHICAGO, ILLINOIS

● PRINCIPLES AND PRACTICE OF SPECTROCHEMICAL ANALYSIS

Norman H. Nachtrieb, **Associate Professor of Chemistry, Institute for the Study of Metals, The University of Chicago. McGraw-Hill Book Co., Inc., New York, 1950. x + 324 pp. 170 figs. 33 tables. 16 × 24 cm. $4.50.**

AS STATED in the introduction, "The approach of the author to his subject is that of the analytical chemist who is more concerned with the use of spectroscopy as a tool for the solution of certain problems in inorganic analysis than in the spectrograph as an instrument of physical research." Throughout the book this approach is maintained; attention is focussed upon the chemical applications.

The book is in two parts. Part I deals with the theory and use of the instruments of analytical spectroscopy. The descriptions of spectrographs, excitation sources, and densitometers are excellent and critical. There is a good elementary presentation of the diffraction of light by slits and gratings and of the optics of prism spectrographs. Photographs are shown of many instruments. The photographic process and its limitations are discussed. This is followed by an unusually clear explanation of the methods used to evaluate photometric data and the errors that may attend such evaluations. A chapter is devoted to direct reading spectrometers and modern instruments employing this principle, such as the ARL "Quantometer." Sections on the origin of spectra, the meaning of spectral terms, and the excitation of spectra complete Part I.

Part II deals with the practice of spectrochemical analysis, taking up separately the problems of metals, refractory materials, and solutions of soluble salts. The section is concluded with a discussion of chemical separations as an aid in spectrochemical analyses. Precipitation, extraction, fire assay, and electrolytic concentration of trace elements are described.

The reviewer feels that this book will be a fine text for classes in spectrochemical analysis. It is well written and the choice of material is excellent. The student who has mastered its contents will have a good grasp of the field, together with enough basic theory to attack new problems intelligently. In parts it is too meager in experimental details but this lack can be readily supplied in supplementary lectures. The only omission that the reviewer notes is lack of a description of the "flame photometer," but this is not serious since enough discussion is given of the Lundegardh flame method to acquaint one with the general principles of flame excitation.

CONWAY PIERCE

POMONA COLLEGE
CLAREMONT, CALIFORNIA

● VITAMINS AND HORMONES. VOLUME VIII

Edited by *Robert S. Harris,* Massachusetts Institute of Technology, and *Kenneth V. Thimann,* Harvard University. Academic Press, Inc., New York, 1950. xi + 342 pp. 37 figs. 54 tables. 15 × 23.5 cm. $6.80.

AS IN the earlier volumes of these truly useful reviews the contributors are eminently well prepared to discuss their several subjects. The first essay is by Theodore F. Zucker and Lois M. Zucker and deals with the "animal protein factor" and vitamin B_{12} in animal nutrition. While mostly treating of recent work in this field, the discussion also includes the background of the subject. The nutritional significance of cobalt as found in B_{12} is discussed.

A subject that has been rather neglected in biochemical review periodicals, "Pyridoxine and fat metabolism," is presented by Henry Sherman. This relationship, he shows, is clearly demonstrated but not yet understood.

W. J. van Wagtendonk and R. Wulzen contribute a review of work, both their own extensive researches and those of others, on the antistiffness factor required by guinea pigs. The data presented and the accompanying illustrations make a convincing case for the existence of this factor. Apparently investigators who fail to demonstrate it do not correctly prepare the deficiency diet.

"Vitamins and metabolism in neurospora" is the subject of a review by Hershel K. Mitchell who gives an instructive picture of the many research uses to which this useful and mutative organism may be put.

A short essay on the physiology of relaxin is presented by F. L. Hisaw and M. X. Zarrow. The biochemistry of relaxin is briefly treated (little is known about it); its comparative physiology is extensively discussed.

"Interactions between estrogens and progesterone" is the subject treated by R. Courier of Paris. The English translation was prepared by A. M. and K. V. Thimann.

An unusually helpful review by R. L. Stehle of McGill University treats of the posterior pituitary hormones other than those acting upon the circulation and the secretion of urine. The latter were reviewed in Volume VII of this series.

The last essay of Volume VIII is by C. W. Shoppee of the University of Wales. The subject is "Steroid configuration." It is a discussion of the evidence obtained from the physical and chemical properties of specific steroids leading to theories of the stearic shape of the molecules. This complex matter, always puzzling to the student not expert in this field, is presented more from the standpoint of the organic chemist then that of the biochemist. For this very reason it is especially useful to the biochemist.

PHILIP H. MITCHELL

BROWN UNIVERSITY
PROVIDENCE, RHODE ISLAND

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The book first covers all of the monofunctional aliphatic compounds; then the monofunctional and polyfunctional aromatic and heterocyclic compounds; and finally the polyfunctional aliphatic compounds. The student is introduced to the subject matter gradually. No compound is used in reactions or in methods of preparation whose structure has not been explained previously.

The history, practical applications, and economic importance of numerous compounds are discussed in some detail. Moreover, topics of current importance are emphasized; autoxidation and organic peroxides; intermolecular attraction by van der Waals' forces, permanent dipoles, and hydrogen bonding; the application and interpretation of the absorption spectra; etc.

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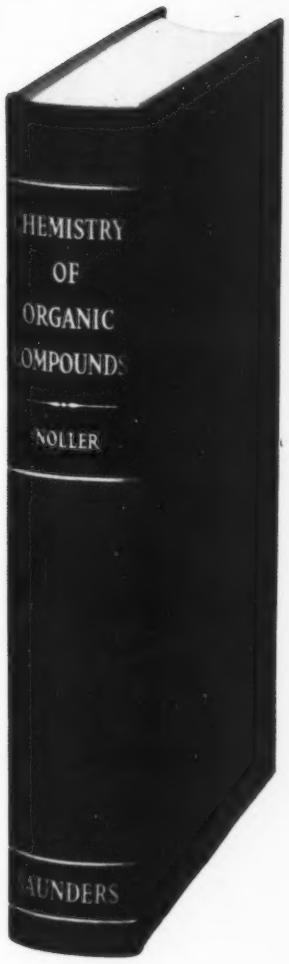
By CARL R. NOLLER, Professor of Chemistry, Stanford University.
885 pages, 6" x 9¼", illustrated. $7.00 *New*



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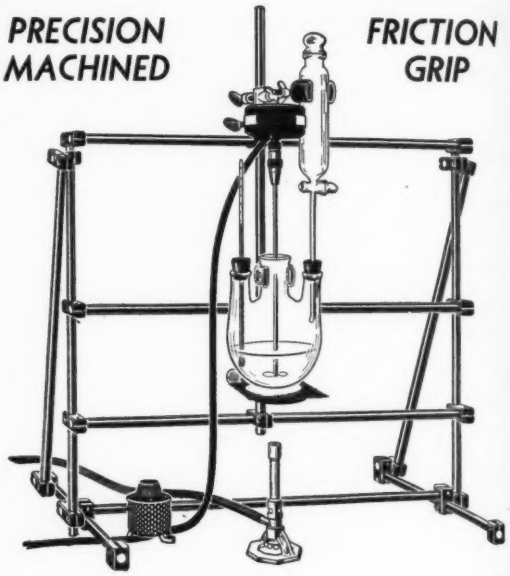

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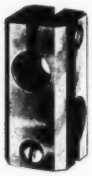

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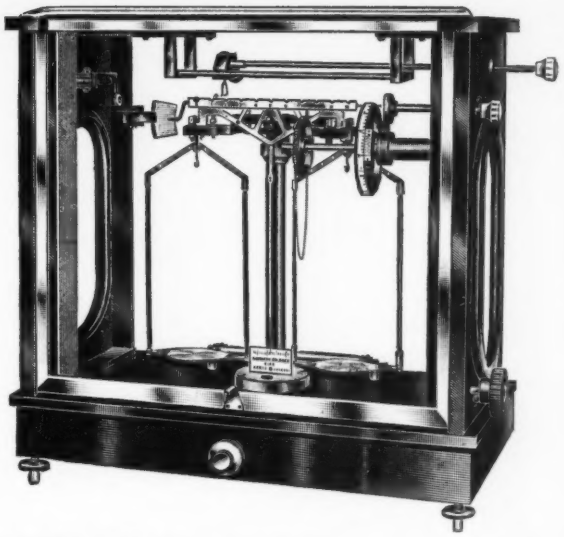

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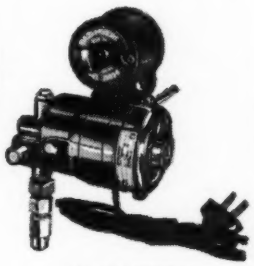

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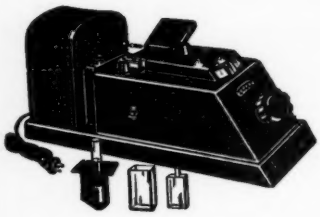

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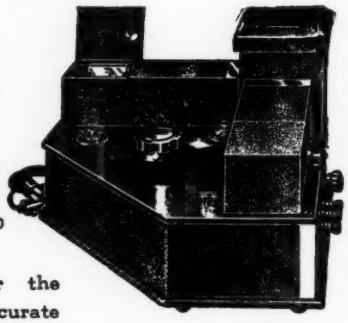

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References

(1) Ind. Eng. Chem. 25-653 (June, 1933)

(2) Ind. Eng. Chem. 25-1112 (Oct., 1933)

(3) National Bureau of Standards Journal of Research 12-241 (Feb. 1934, R.P. No. 649)

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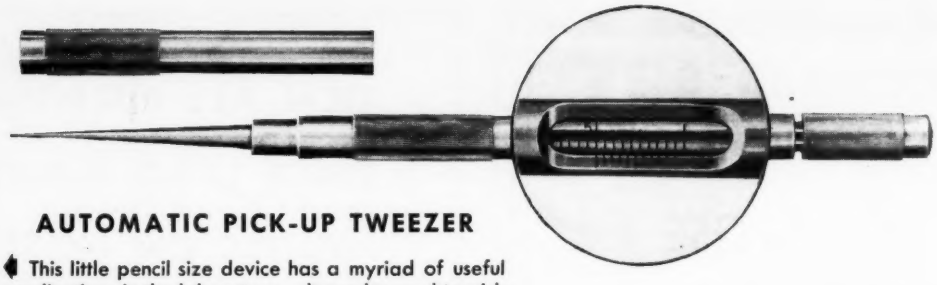

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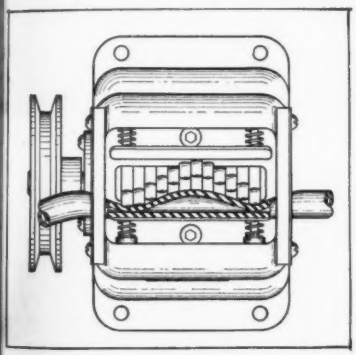
Out of the Editor's Basket

New Laboratory Pump

No contamination and no corrosion are advantages of the new inexpensive pumping unit announced by E. & M. Enterprises, Middleport, New York.

Called the Sigmamotor, the new unit provides continuous liquid flow by means of a series of "fingers" that exert pressure on flexible tubing. There is no chance of contamination from metal parts or of adverse corrosive effects from the fluid being handled, since the liquid flows only through the rubber or synthetic tubing and does not come in contact with any mechanical parts.

Designed to pump liquids or gases, the Sigmamotor can readily take care of solids in the solution, the company states. It will handle from $1^1/_2$ to 30 gallons per hour without speed changes.



Sigmamotor can be easily installed in any system with commercial fittings, and can be quickly changed from one fluid to another. If desired, the machine can handle a number of different fluids at the same time, entirely independent of each other. It can provide proportional flows and extremely small flows.

Full information about the Sigmamotor can be obtained by writing E. & M. Enterprises, Inc., 528 Vernon Street, Middleport, New York.

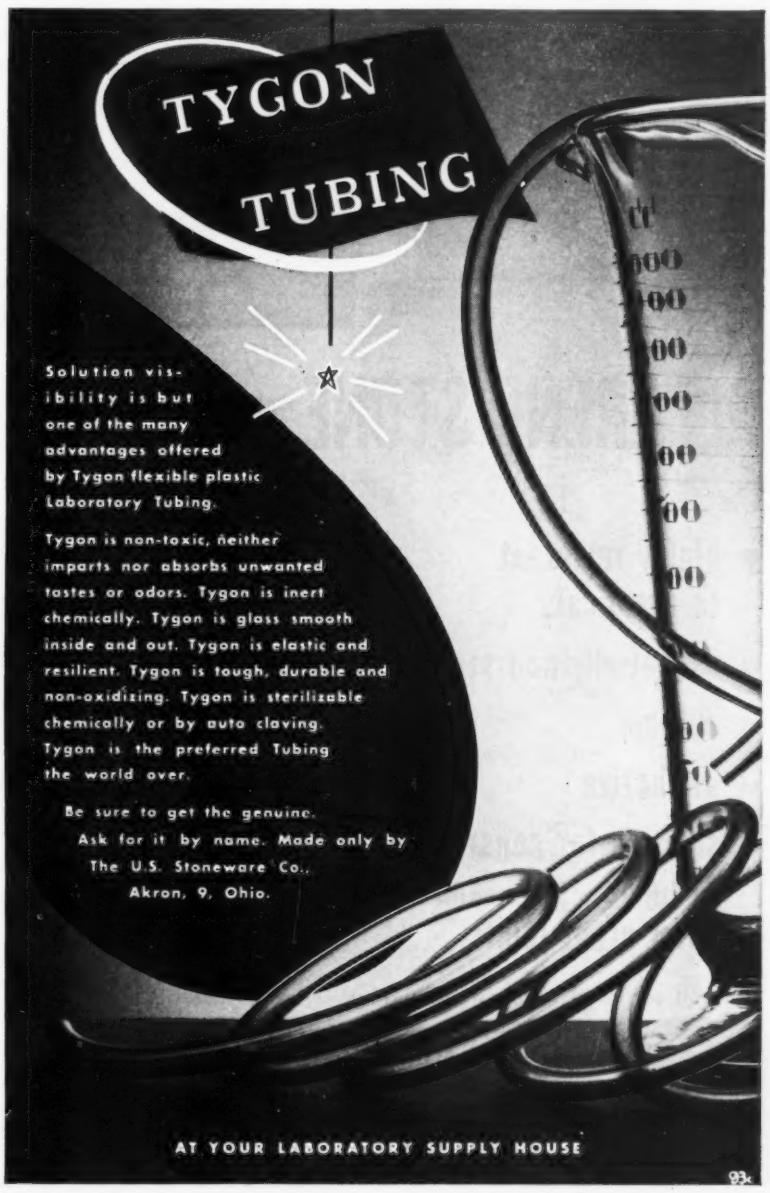
Small Mercury Cleaning Units

New, small mercury cleaning units have just been announced by the Bethlehem Apparatus Co., Hellertown, Pennsylvania. Designed as "little brothers" to the 25-lb. mercury oxifier and Type F filter now in use in many industries and laboratories, they clean mercury in 5-lb. lots for those users who require only small quantities of the metal.

The small model works on the same principle as the larger model in reclaiming mercury contaminated by dissolved base metals. The oxifier, powered by an electric motor, violently agitates the mercury for from 2 to 4 hours and provides maximum air contact with the mercury droplets. As base metal contaminations are thoroughly aerated, they oxidize, form skins, and precipitate from the mercury as metallic oxide powders. These can then be readily separated from the clean mercury by use of the Bethlehem Type G Filter.

Where it is definitely established that mercury contamination consists only of floating foreign matter, and not of dissolved base metals, the small type G filter of the unit is completely effective alone. This filter operates on the gold adhesion principle and removes such impurities as dust, oxide scums, oil, water, and acid residue.

The cleaning process is so effective that mercury cleaned in this way is satisfactory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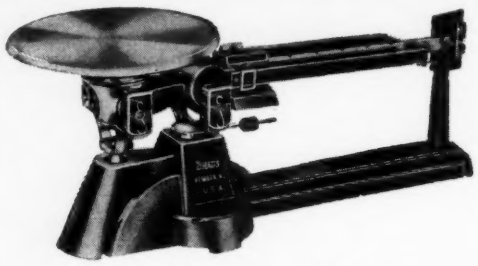
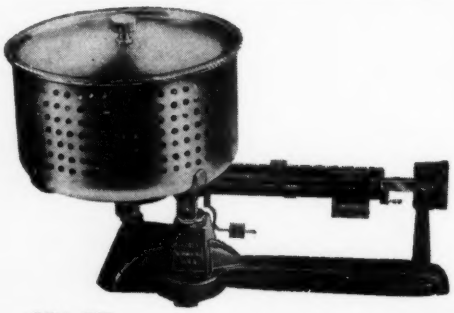


SGA 1007-1



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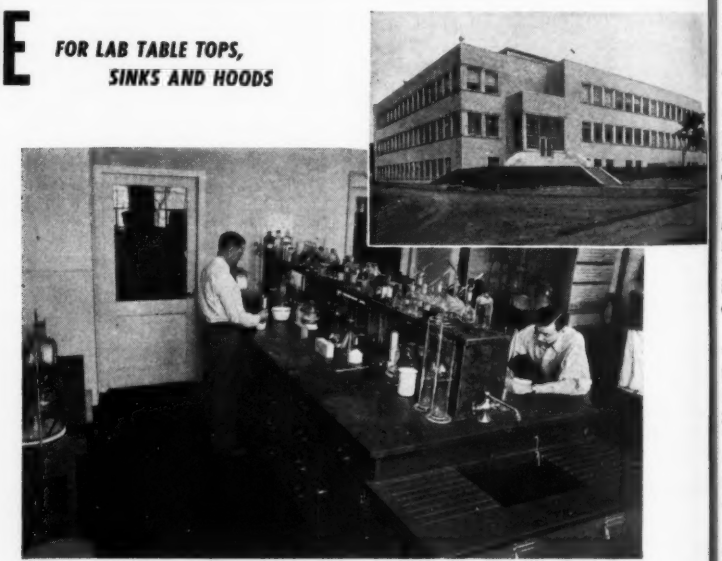

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The new units are compactly built. The oxifier requires table space of 9 × 5 in. and stands 7 in. high. It weighs 8 lbs. Its 1/70 h.-p. motor operates on 115-volt, 60-cycle a.-c. current. The filter weighs 1 lb. 2 oz., and occupies a table space of 3 1/2 in. diameter by 6 1/2 in. high.

The oxifier requires attention only at the beginning and end of the run. The manufacturer claims that the entire cleaning operation can be carried out by anyone who can turn an electric switch.

Literature Available

"Nuclear Data," Circular 499, 310 pages, is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. These tables present a comprehensive collection of experimental values of half lives, radiation energies, relative isotopic abundances, nuclear moments, and cross sections. Decay schemes and level diagrams are provided wherever possible. The first volume is to be followed by supplements at six-month intervals.

Instruments and apparatus developed during the past two years are illustrated and described in a six-page folder published by Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pennsylvania. This company has also announced the publication of a newly revised edition of the 40-page booklet entitled "Manual of Laboratory Safety."

A 16-page data sheet on the "Modification of Starches, Proteins and Gums with Peroxygen Compounds" has been released by the Buffalo Electro-Chemical Co., Buffalo, New York. Practical applications, including the processing of textiles and paper, the production of starches for confectionery and domestic use, the preparation of sizing and adhesives, etc., and a selection of literature references are contained in this data sheet.

Water-purification equipment is described in an eight-page folder available from the Illinois Water Treatment Co., Rockford, Illinois. Information covers ion-exchange equipment, including softeners, hydrogen zeolite, and deionizers.

"A Simplified Guide to Bakelite and Vinylite Plastics and Resins" is a 24-page booklet published by Bakelite Division, Union Carbide and Carbon Corporation, 300 Madison Ave., New York 17, New York. It classifies and describes the various forms of Bakelite phenolic, styrene, polyethylene, and Vinylite plastics and resins.

A compilation of technical literature on electron microscopy (Circular 502) is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Only books and papers published before January 1, 1950, are included.

The Winter 1951 issue of *Instrument News*, published by the Perkin-Elmer Corporation, Norwalk, Connecticut, includes articles on oscillographic methods for infrared spectrometry, theory and design of high-speed thermocouples, and water conditioning by flame photometry.

Tongs and Dishes

A new design of laboratory tongs has been introduced by La Pine & Co., 121 W. Hubbard St., Chicago 10, Illinois. It is called the "nip tong" and is operated by a gentle finger squeeze against a spring release.

Stainless steel dishes, made by the same producers, will find a variety of uses in the laboratory.

Models of Silicones

A new silicon atom model has been added to the Fisher-Hirschfelder-Taylor Atom Model Kit, enabling models of complex silicone molecules to be made. The new atom model, as well as previous types, is scaled exactly in the ratio of 10^8 to 1 so that each cm. of an assembled molecule is equivalent to 1 Å. The models are distributed by Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pennsylvania.

New Electronic Parts Catalog

A new 130-page catalog of electronic components is now being offered by Sun Radio & Electronics Co., Inc., 122–124 Duane Street, New York 7, N. Y. Designed particularly for industrial purchasing agents, research laboratories, universities and trade schools, this new catalog has been compiled in such a manner that full technical information is given on all items listed as well as illustrations and drawings on many. Copies may be had by writing Sun Radio & Electronics Co.

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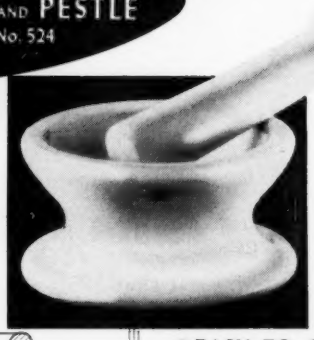

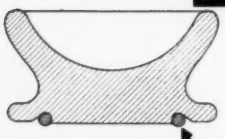

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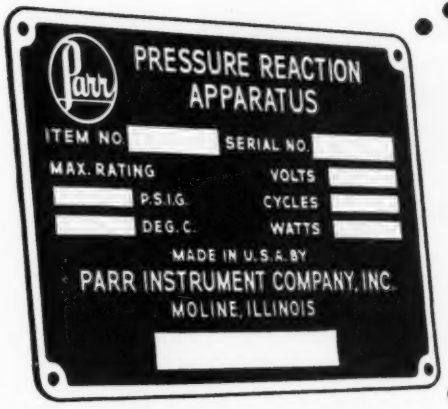
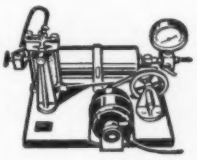
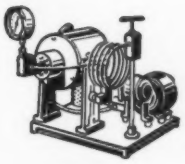


Apparatus for Hydrogenation and other Pressure Reactions



Low Pressure Shaker Type



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Medium Pressure Stirrer Type

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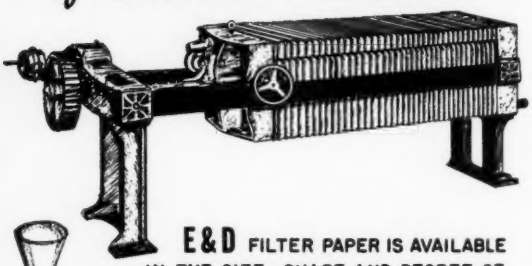

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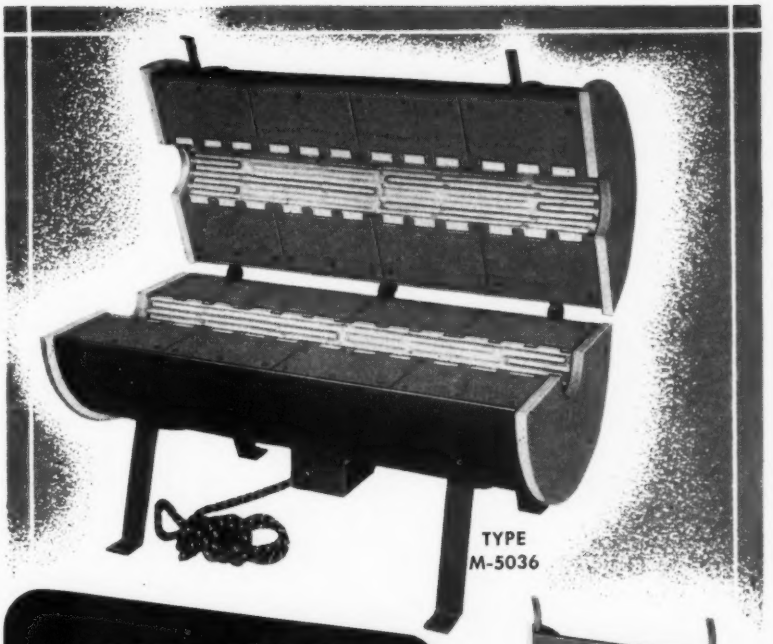

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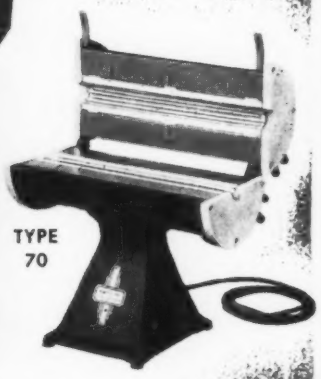

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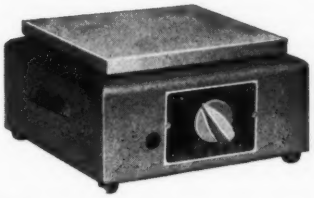

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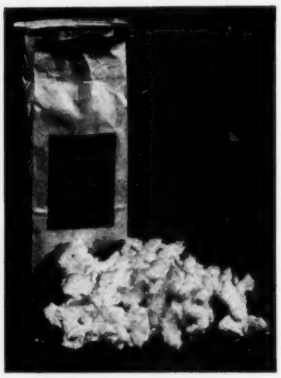

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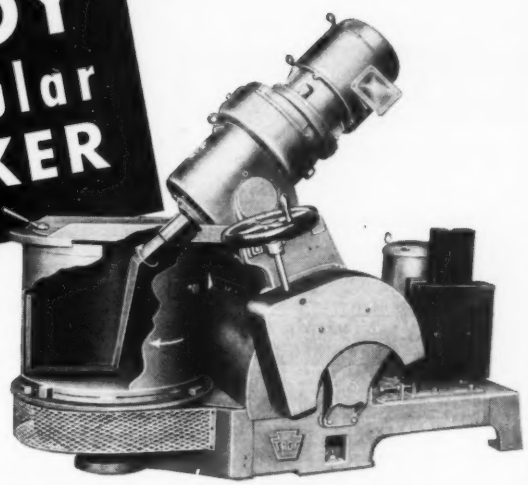

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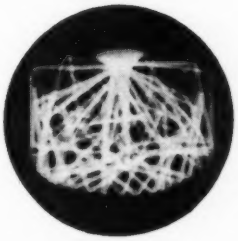

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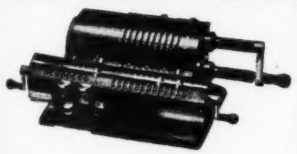

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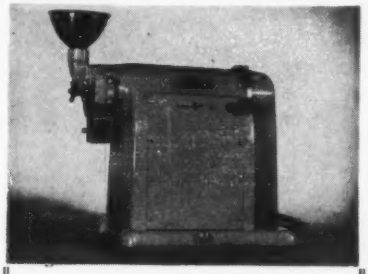

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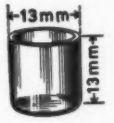

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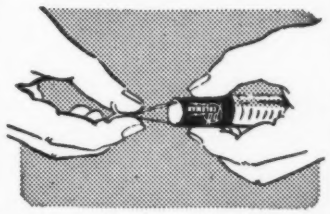

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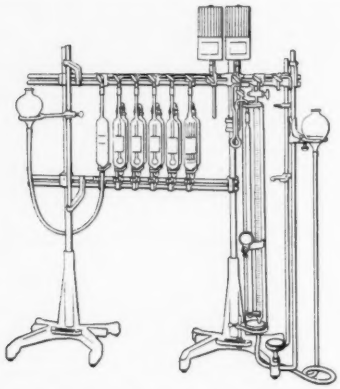

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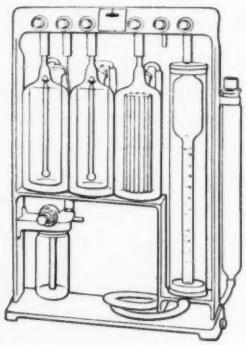

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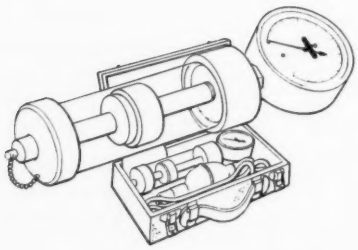

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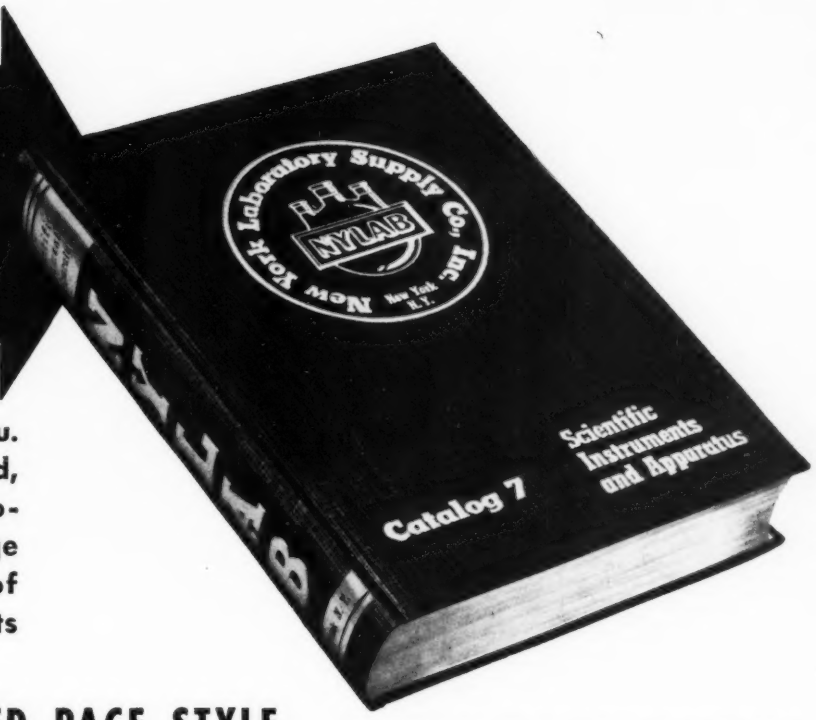

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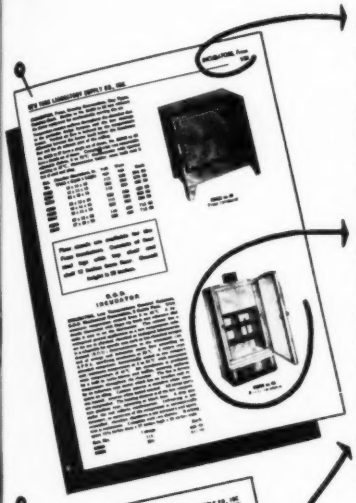

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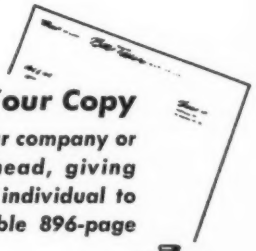

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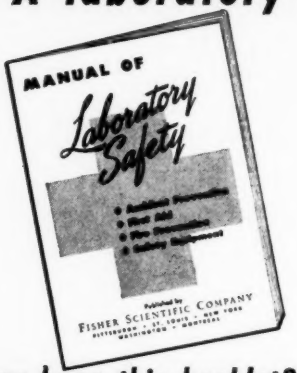

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